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AMERICAN CERAMIC SOCIETY

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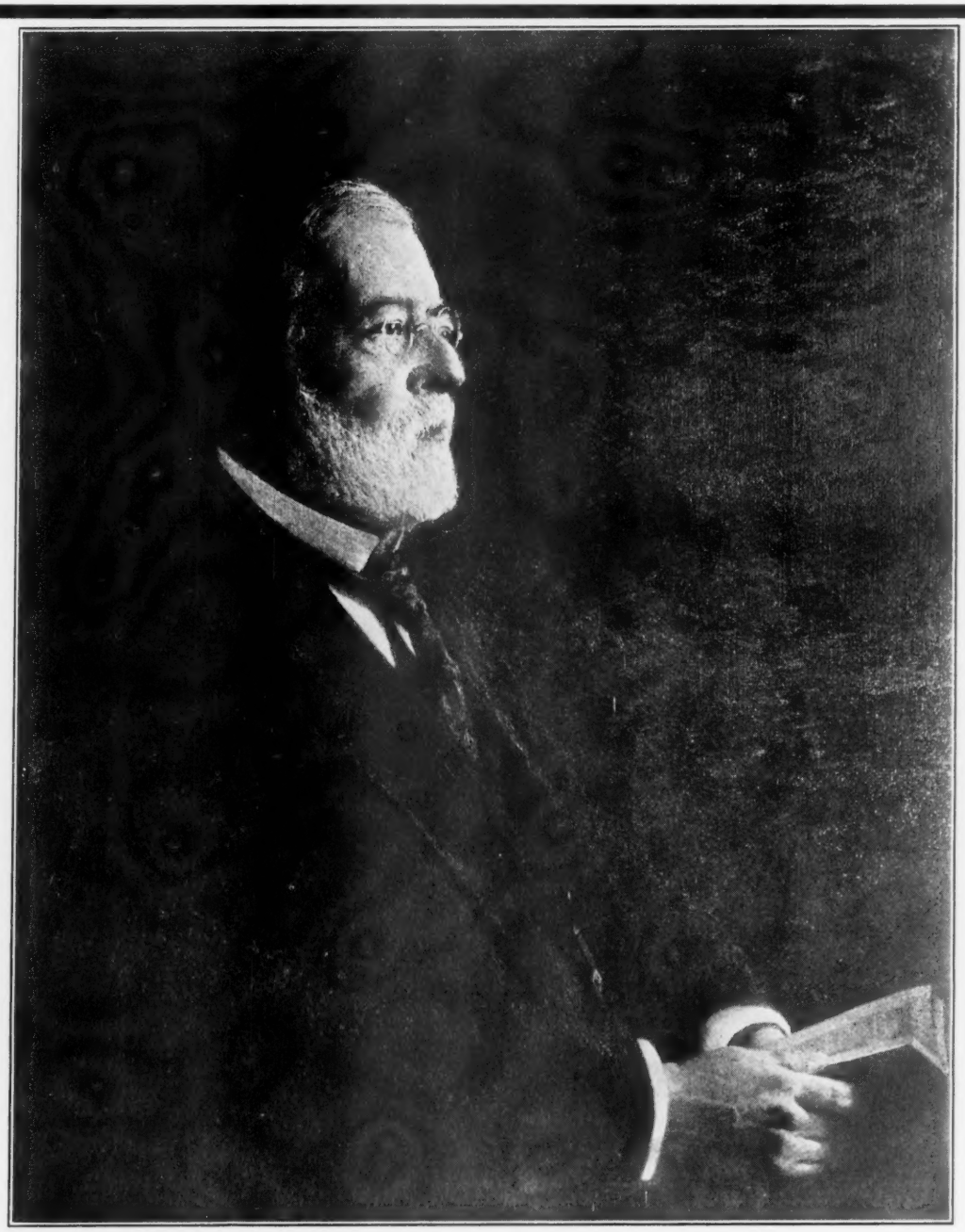

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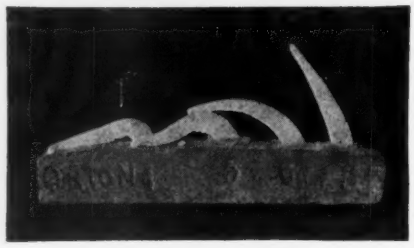

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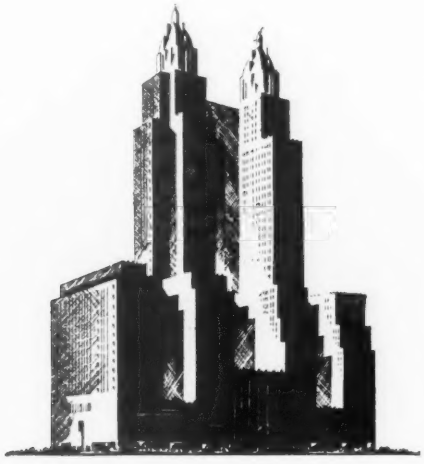

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Electro Refractories & Alloys Corp.

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American Rolling Mill Co.
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Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
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Ceramic Color & Chemical Mfg. Co.
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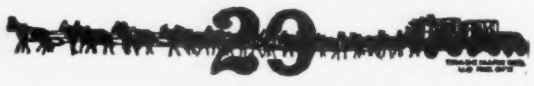
Chicago  **Los Angeles**

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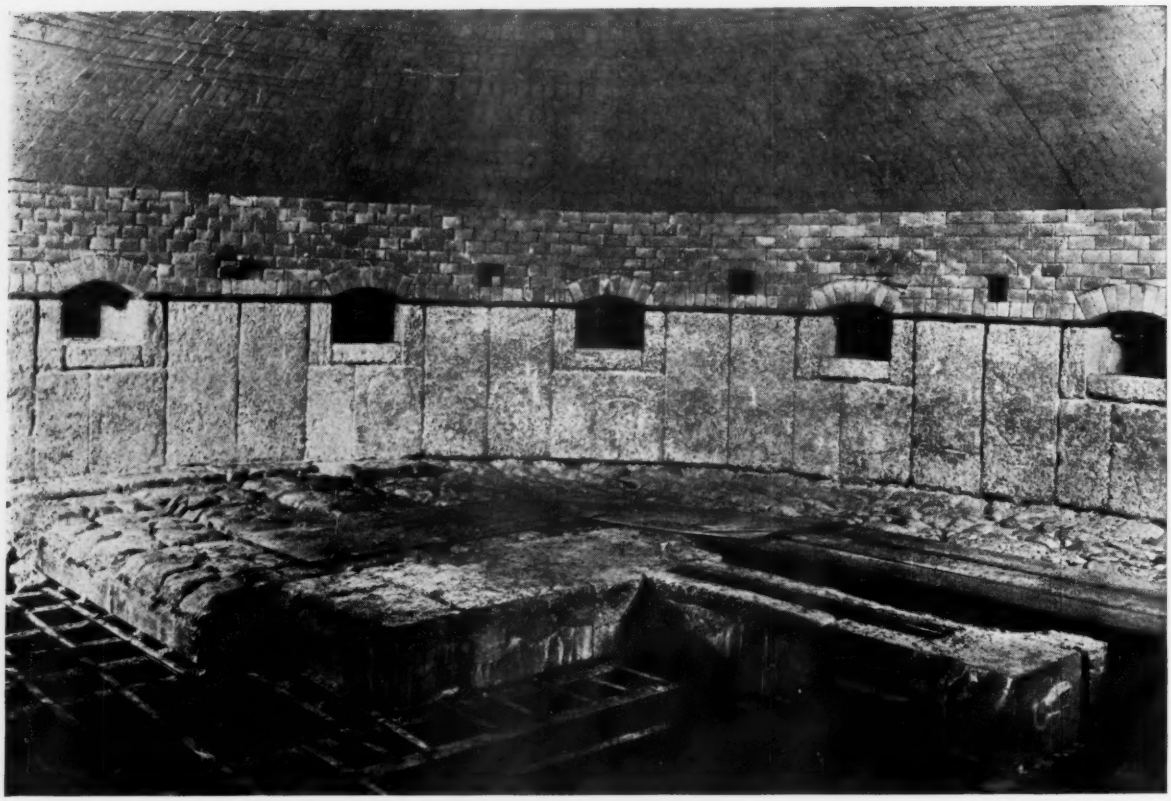

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VOLUME 15 **SEPTEMBER, 1936** **NUMBER 9**

PAPERS

PROPERTIES AND PERFORMANCE OF SILICON CARBIDE BATTS IN THE PORCELAIN AND OTHER CERAMIC INDUSTRIES*

By Grant S. Diamond

I. Introduction

In most continuous kilns, the sagger type of loading is being replaced by open setting with the use of shelves or batts composed of silicon carbide. A refractory of 85% silicon carbide is particularly suitable for use in such batts, owing to the high tensile strength and modulus of rupture at operating temperatures. Silicon carbide is also resistant to spalling because of the bond strength and the relatively high thermal conductivity and low thermal expansion. These properties produce a durability much better than many other materials and thus counteract the cost of silicon carbide which is several times higher than ordinary refractories.

Silicon carbide batts, however, have had defects which cause premature failures, *i.e.*, (1) excessive warping, (2) cracking of the batts in a direction parallel to one side of the batt, (3) general disintegration due to growth and distortion by oxidation, (4) accumulation of a film or layer of glost material on the batt, and (5) staining of the ware by iron oxide which develops on the surface of the refractory.

These defects have been the motive for considerable research in the last three years in this laboratory and this paper is the first report on these studies.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (White Wares Division).

II. Results of Researches

(1) Warping

High-temperature firing of silicon carbide batts in the manufacturing plant has practically eliminated warping in service. This high-temperature firing necessitated the use of a very refractory bond to prevent high rejects in production.

(2) Cracking

The parallel crack is the most disastrous to the life of batts. To arrive at the cause for this type of crack, tensile strengths and modulus of rupture determinations were made on samples taken from finished batts, 32 by 18 inches, and from several locations on the batt.

From these samples it was found that the lengthwise strengths were invariably much greater than the crosswise strengths (1050 and 400 pounds per square inch, respectively). This difference in strengths was due to laminations caused in molding the batts. The cure was obvious, although it required considerable experimenting with grog size, moisture content, and method of molding. After these tests, it was possible to produce batts consistently with a directional variation of not more than 250 pounds per square inch and with an average strength of 1100 pounds per square inch.

(3) Oxidation

The resistance to oxidation was improved by

applying a ceramic coating which rendered the batt practically impermeable to oxygen. In addition, the pore size was reduced materially which made the batt fairly impermeable without entirely relying on the coating or glaze. If

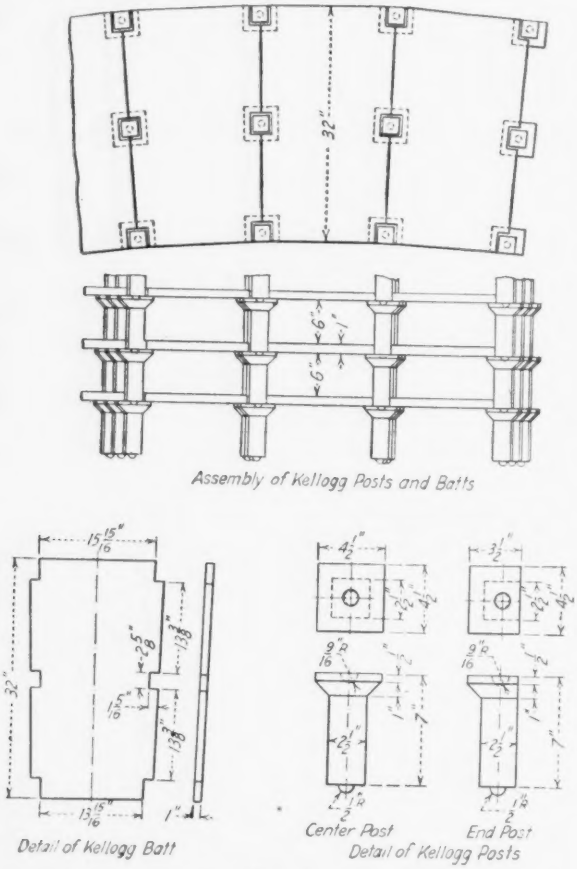


FIG. 1.

oxygen can not penetrate the refractory, it is apparent that oxidation and disintegration will be greatly retarded. Oxidation can be practically entirely prevented at certain temperatures. At other temperatures, a retarding of the disintegrations only can be obtained.

(4) Dripping and Iron Spitting

In porcelain firing, the refractory material requires special treatment by magnetic separation and washing with acid to remove all iron. The bond also must be iron-free.

One type of dripping for which a cure has not as yet been found is the accumulation of glost material from the ware in the one-fired bisque glost kiln. This glost material seems to migrate or is "drawn" by the refractory body. In those kilns which use clay saggers, it has been observed that a porous sagger will soak up this glost material and give less trouble than a dense sagger. As a manufacturer of silicon carbide, the writer hesitates to recommend a more porous batt for this service, but there are possibilities that such a batt might localize the drippage considerably. The safest procedure seems to be to remove the batts from the setting and to rub the glass off with a brick or grindstone.

(5) Floating-Shelf Construction

This is shown in Fig. 1. The dimensions are not important, but serve merely as a basis for criticism and suggestions. The posts or pillars, and not the batts themselves, should carry the accumulative loads. The usual type of setting is too tightly bound together, and any shifting by setting of the car floor top, any variation in expansion and contraction, or any shrinkage of the wad clay or the clay posts causes uneven strains on the batts. A floating-shelf construction may double the batt life and prove a great economy. It will eliminate the two types of cracks previously mentioned, the curving crack near the corner posts and the crosswise crack near the center of the batt. It will also simplify the removal of batts for cleaning accumulated glost drippage.

ELECTRO REFRACTORIES & ALLOYS CORPORATION
BUFFALO, NEW YORK

PYROPHYLLITE, A NEW DEVELOPMENT—THE GERHARDT DEPOSIT*

By B. C. Burgess

Abstract

The Gerhardt deposit is located near Staley, Randolph County, North Carolina. Its discovery, prospecting, and development are described, as well as its geologic relations, form, structure, and mineralogy. Sampling, analysis, and production methods are given.

I. Introduction

The pyrophyllite deposits of North Carolina have been known for more than one hundred years and they have been described by Stuckey,[1] whose work also gives a description of the region in general and of other mineral deposits.

II. Composition and Use

Pyrophyllite is a hydrous aluminum silicate ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O$), with a hardness between 1 and 2, and a specific gravity of 2.8 to 2.9. It resembles talc as to softness and greasy feel. It is not common to find pyrophyllite in large comparatively pure deposits. North Carolina is the only producing state.

Pyrophyllite is used in ceramics, textiles, paper, paint, cosmetics, rubber, plastic compounds, and roofing.

III. History

Paul and Charles Gerhardt came east in 1911 when gold mine development in Mexico ceased to be either safe or profitable. Success had accompanied their gold mining in the southern republic and they had come to North Carolina to settle down on a farm in Moore County with the idea of returning to the status of country gentlemen. However, the old adage, "once a miner always a miner" asserted itself, and when their farm wagon wheels in 1916 brought up a fine silky white material, the Gerhardt brothers could not resist the urge to return to mining.

They organized a company, sunk a two-hundred foot shaft, and developed the mine.

A mill was built and considerable business was built up by the Gerhardt Brothers, but in the course of a few years they lost control of the property.

Following this financial setback, they set out to find a high-grade pyrophyllite deposit. A systematic search was made of the entire area in which pyrophyllite was known to occur. Many deposits were examined and rejected because of inferior quality. They were finally directed to "Soapstone Mountain," four miles due west of Staley in Randolph County, where natives told them their ancestors had obtained a tough, white stone easily worked into monuments.

The search ended there. Soapstone Mountain is the outcrop of the Gerhardt pyrophyllite deposit. Figure 1 shows the "Mountain" from the north.

IV. Early Development

Test pits were sunk around the sides of the hill to determine the extent of the deposit and the dip and strike of the wall rocks. At the top where the axe marks of the tombstone hunters are still visible, almost a quarter of an acre of pyrophyllite is exposed, practically free from overburden.

When preliminary work satisfied them as to the size and quality of the deposit, a contract was obtained with the Tallassee Power Company (predecessor of Carolina Aluminum Company, Badin, N. C.) for pyrophyllite to be used as the source of an aluminum-silicon alloy.

To obtain the material for this contract, a tunnel was run into the mountain from the toe of the steepest slope toward the axis of the hill. Figure 2 shows Paul Gerhardt standing in the approach cut to this tunnel.

At a point near the center of the deposit, laterals were run to the right and left. About half-way out on the present length of the left lateral (see Fig. 3), a crevice or old water course was struck. A raise was run up alongside of this and subsequently expanded into the "glory hole" (Fig. 4).

V. Geology

The pyrophyllite area of North Carolina lies

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Materials and Equipment Division). Received April 9, 1936.

[1] J. L. Stuckey, "The Pyrophyllite Deposits of North Carolina," *N. C. Dept. of Conservation and Development Bull.*, No. 36, 1928.

FIG. 1.—View of Soapstone Mountain from the north.

in what is known as the Carolina slate belt. This consists of a series of interbedded formations in the lower portion of the Piedmont Province. These formations consist chiefly of slate, tuff, volcanic breccia, and minor areas of rhyolite and andesite.

Much folding has taken place accompanied by shearing and crushing. Regional metamorphism has so altered the strata that it is difficult to identify the parent rocks.

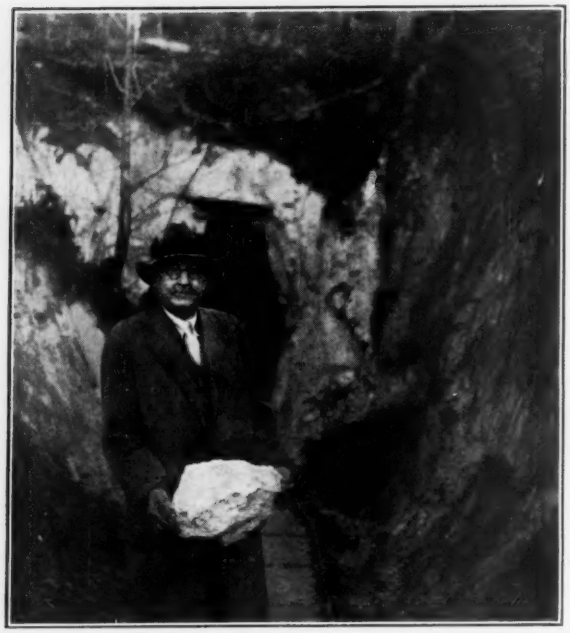


FIG. 2.—Paul Gerhardt at the approach cut to the tunnel.

Stuckey and previous writers place the age of both the pyrophyllite and enclosing formations as pre-Cambrian. The author is not in a position to argue this as to the pyrophyllite deposits in

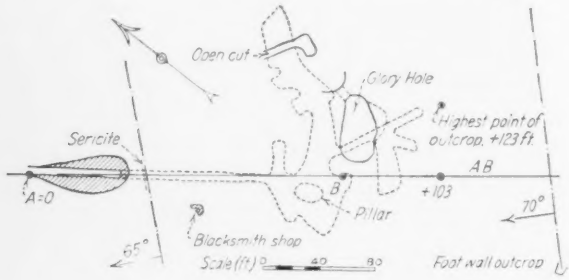


FIG. 3.

general, but in the case of the Gerhardt deposit, there is at least a suggestion of later alteration and re-deposition which deserves investigation. In all the other deposits visited, the sericite is disseminated through the pyrophyllite and the latter is interlaminated, corresponding, no doubt, to the structure of the rocks it replaced. In the

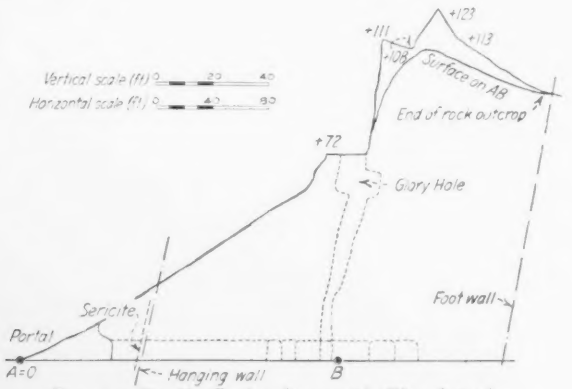


FIG. 4.—Profile Gerhardt pyrophyllite deposit.

Gerhardt deposit there is a separate bed of sericite with practically none of this mineral disseminated through the pyrophyllite; the pyrophyllite is also massive with only an occasional hint of lamination.

VI. Structure and Form

Soapstone Mountain forms an eminence or monadnock in an otherwise level or gently rolling country.

Folding characterized elsewhere in the area is not seen in the Gerhardt deposit nor is there any evidence of faulting.

The deposit as exposed at the surface and by present underground development has nearly

parallel walls, with a northeast strike. The walls are approximately 280 feet apart at the tunnel level. This compares with about 50 feet as the maximum width of other deposits being worked at the present time.

Except for the quarter acre exposed on the top of Soapstone Mountain, the deposit does not outcrop plainly in either direction along the strike. There is, however, plenty of float for a distance of 1500 feet to the northeast, indicating probable extension of the deposit that far.

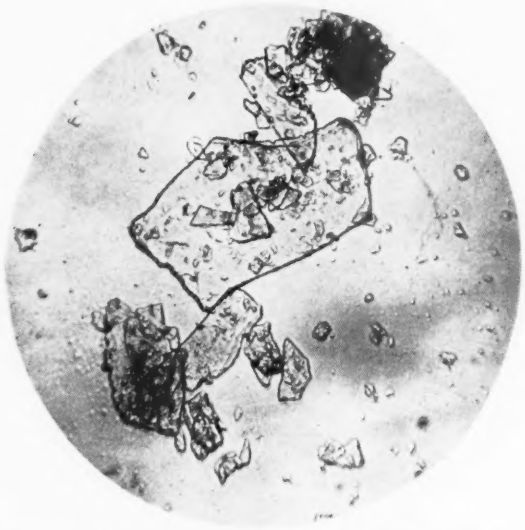


FIG. 5.—Photomicrograph of 200-mesh mica, 200×.

The hanging and footwalls dip at 65° and 70°, respectively, to the northwest, representing a divergence of 5° in the downward extension of the deposit.

The tunnel level is some 30 or 40 feet above the nearby stream level, and the outcrop rises 123 feet above the tunnel so that a considerable tonnage can be mined here above water level. At other pyrophyllite deposits working below water level, pumping is an item of considerable expense and the presence of water in the ground causes other problems which at times become serious.

VII. Mineralogy

The principal minerals found in the pyrophyllite deposits of North Carolina are pyrophyllite, granular quartz, vein quartz, andalusite (including kyanite and other minerals in this group), sericite, pyrite, chloritoid, orthoclase, albite, andesine, topaz, lazulite, chlorite, hematite, magnetite, epidote, zircon, titanite, and rutile. Stuckey[1] also mentions zeolites and apatite.

The analyses of the first six of these minerals, according to Dana,[2] are as follows:

	Pyrophyllite	Quartz	Andalusite	Sericite	Pyrite	Chloritoid
Silica	66.7	100.0	36.8	45.2		23.8
Alumina	28.3		63.2	38.5		40.5
Iron					46.6	28.5
Potash				11.8		
Sulfur					53.4	
Water	5.0			4.5		7.2
	100.0	100.0	100.0	100.0	100.0	100.0

In the Gerhardt deposit some of the granular quartz is disseminated through the pyrophyllite, but there are zones of almost chemically pure pyrophyllite. Such vein quartz as the deposit contains is in well-defined lenses several inches thick and easily removed in mining. As was stated under "Geology" (section V), the sericite is in a separate vein. It is found along the hanging wall and is about 18 inches thick. The other minerals of lesser importance are either nonoccurrent at the Gerhardt deposit or they are confined to small water courses or pockets so that they can be easily segregated in mining.

Pyrophyllite occurs in two forms, foliated and massive. Most of the North Carolina pyrophyllite deposits are of the foliated type, but in the Gerhardt deposit the massive type predominates. The foliated type is sometimes fibrous and radiated, making interesting cabinet specimens. There is an erroneous impression among the miners that pyrophyllite grinds to needlelike particles. Microscopic examination shows that fine grinding develops only the characteristic platy structure. Figure 6 is a photomicrograph of an average sample of 200-mesh pyrophyllite. Compare it with Fig. 5, 200-mesh mica, and Fig. 7, 200-mesh talc.

The Gerhardt pyrophyllite pulverizes to a clean white color, plus five on the pigment scale. It fires white in ceramic bodies at cones 5 to 10.

VIII. Sampling

Preliminary to acquiring the property, the writer's organization made a survey of the surface and workings and took 42 channel samples. The property is in five tracts aggregating 212 acres. The Gerhardt deposit extends along the north-

[2] E. S. Dana, A Textbook of Mineralogy. John Wiley & Sons, 1905.

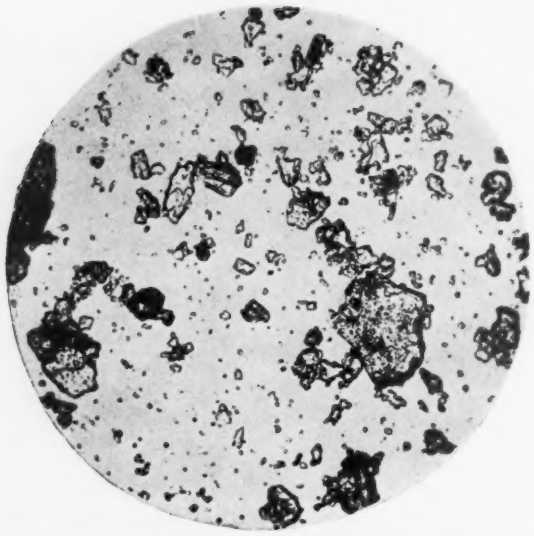


FIG. 6.—Photomicrograph of 200-mesh pyrophyllite, 200×.

cast side of this acreage and with the long dimension of it.

The sampling disclosed the segregation of minerals already described in this paper under the heading "Mineralogy." The following analyses of typical samples will illustrate this:

	(1)*	(2)	(3)	(4)	(5)	(6)	(7)
Silica	76.32	73.50	70.26	69.90	69.38	83.34	77.22
Alumina	19.80	22.53	24.95	25.13	26.02	13.93	15.95
Iron	0.18	0.09	0.08	0.07	0.08	0.13	0.35
Calcium	.14	.08	.16	.16	.14	.42	Tr
Magnesium						.04	
Potash	.27		.13	.00	.00	.00	3.54
Soda	.07	.06	.31	.08	.24	.18	0.93
Loss	3.44	3.95	4.32	4.67	4.50	2.20	2.08
	100.22	100.21	100.21	100.01	100.36	100.24	100.07
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Pyrophyllite	66	79	85	88	89	48	5
Quartz	31	21	12	11	9	51	57
Sericite	3		3	1	2	1	38

* (1 to 5) pyrophyllite, (6) granular quartz, (7) sericite.

It will be noted that even the quartz and sericite show a considerable pyrophyllite content.

Analyses of other deposits are given by Stuckey,[1] Pratt[3], and Sproat.[4]

IX. Reserves

Recovery from workings to date has averaged in excess of 80%. Using 60% and a volume defined by the surface and ends of present underground workings (160 by 280 by 70), with a cubic contents factor of 12, gives fully developed reserves of 156,800 tons. In addition, prospective reserves may be estimated at 1000 tons per foot of extension beyond the present headings and above the tunnel level. There is some evidence to indicate the possible depth of the pyrophyllite as 500 to 800 feet below the summit of Soapstone Mountain. If the deposit extends laterally only twice the width developed, it will contain 7800 tons of pyrophyllite per foot of such downward extension.

Stuckey, after studying the North Carolina pyrophyllite deposits for several years and making visits to the Gerhardt mine every few months to watch its development, says,[5] "The mine has been opened up by an expert and shows a large reserve of mineral. There is, without doubt, one million tons of pyrophyllite of high grade in sight and probably a great deal more available."

The Gerhardt pyrophyllite deposit is unique as to size, purity, and accessibility.

Acknowledgments

The writer wishes to thank J. L. Stuckey and A. F. Greaves-Walker of North Carolina State College for first acquainting him with the possibilities of the Gerhardt deposit. He is indebted to Paul Gerhardt for historical data and assistance with the surveys and sampling, to the Carolina Alumina Company for analysis and other information on the tonnage of pyrophyllite they received, to C. R. McIver for his coöperation in plans for production and operation, to R. W. Sullivan, of Krebs Pigment and Color Corporation, for the photomicrographs furnished, and to Frank L. Hess and H. M. Urban for checking the manuscript.

TENNESSEE MINERAL PRODUCTS CORPORATION
SPRUCE PINE, NORTH CAROLINA

FIG. 7.—Photomicrograph of 200-mesh talc, 200×.

[3] J. H. Pratt, "Talc and Pyrophyllite Deposits of N. C.," *Econ. Paper*, No. 3 (1903).

[4] I. E. Sproat, U. S. Pat. 1,984,163, Dec. 11, 1934.

[5] J. L. Stuckey communication to C. R. McIver, November 5, 1934.

THE EXPANSION OF PYROPHYLLITE*

By A. F. Greaves-Walker and C. W. Owens, Jr.

Abstract

The macrocrystalline variety of pyrophyllite is known to expand several hundred per cent in volume during dehydration. In the cryptocrystalline variety the expansion is much less. The results of an investigation of the expansion of a commercial grade such as is used in the whiteware industry is given.

I. Introduction

Pyrophyllite has been used to some extent in ceramics for more than eighty years.[1]

Stuckey, in his doctorate dissertation at Cornell University in 1925 and again in a North Carolina geological report,[2] states that the North Carolina material has in past years been used in ceramic bodies.

Pratt, another state geologist of North Carolina, in 1899 suggested the possibility of using it as a refractory.

It was observed, in the various researches at the University of North Carolina, that there has been a wide divergence of results concerning the effect of heat on volume changes in the ceramic bodies containing pyrophyllite. Shelton,[3] using finely ground material, reported that the higher the pyrophyllite content in a body, the greater its shrinkage. Lloyd,[4] in attempting to develop a lightweight insulator composed principally of pyrophyllite, found that only with certain types of the material and certain grain sizes could he get the desired expansion and that the amount varied widely. The junior author of this study has found that a body made up of finely ground pyrophyllite would show shrinkage, while at the same temperature a body of identical composition but of larger particle size would show expansion. It became necessary, therefore, to determine the cause of these conflicting results and the conditions under which they were obtained.

II. Experimental Work

The material was of medium grain size and contained very few needles of the radiated pyrophyllite. The data obtained will apply to all commercial shipments made from mines producing either type, although it would not apply to hand-picked specimens of the radiated granular type containing quantities of needles. The sample used will be referred to as a radiated granular type and is about halfway between the massive compact and the radiated granular types. As the needles of pyrophyllite in the radiated granular type appeared to have an unusually large expansion, the expansion of several pieces of this type was also determined.

III. Method Used

Inasmuch as all other methods gave inconsistent results, it was decided to make the pyrophyllite into dry-pressed specimens, $4^1/_4$ by $2^1/_2$ by $^3/_8$ inch, and determine their expansion in a thermal-expansion furnace of the type shown in Fig. 1. As the larger grained pieces would not bond when dry, 15% of a highly plastic ball clay was used as a bond. The clay was ground through a Tyler standard 40-mesh sieve and was well mixed with the pyrophyllite while dry; 7% water was added, which made the tile strong enough to handle. The tile were pressed in a hand-operated screw press at approximately 50 pounds per square inch, dried at 212°F for 24 hours, measured, and placed in the "expansion furnace."

The furnace was fired to the desired temperature and held until the dial, accurate to $^1/_{10,000}$ inch, showed no further movement. A reading was taken and the temperature raised to the next stage. The furnace was calibrated at the beginning of each series of runs by using a speci-

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division).

[1] (*a*) E. Emmons, "Geological Report of the Midland Counties of North Carolina," *N. C. Geol. Surv.*, 1856.

(*b*) C. H. Clapp, "Geology of the Alumite and Pyrophyllite Rocks of Kyuoquot Sound, Vancouver Island," Summary Report, Geol. Surv., Can. Dept. of Mines for 1913.

[2] J. L. Stuckey, "The Pyrophyllite Deposits of North Carolina", *U. S. Geol. Surv. Rept.*, 1928.

[3] G. R. Shelton, "Pyrophyllite, a New Ceramic Raw Material," *Jour. Amer. Ceram. Soc.*, **12** [2] 79–82 (1929).

[4] (*a*) A. S. Lloyd, "Development of a Lightweight Insulator," unpublished thesis, Dept. of Ceramic Engineering, Raleigh Unit, Univ. of North Carolina, 1935.

Other references on this subject are (*b*) E. S. Dana, Textbook of Mineralogy, p. 683. John Wiley and Sons, Inc., New York, 4th ed. by W. E. Ford (1932) and (*c*) J. L. Stuckey, "Dehydration Temperature of Pyrophyllite and Sericite," *Jour. Amer. Ceram. Soc.*, **7** [10] 735–37 (1924).

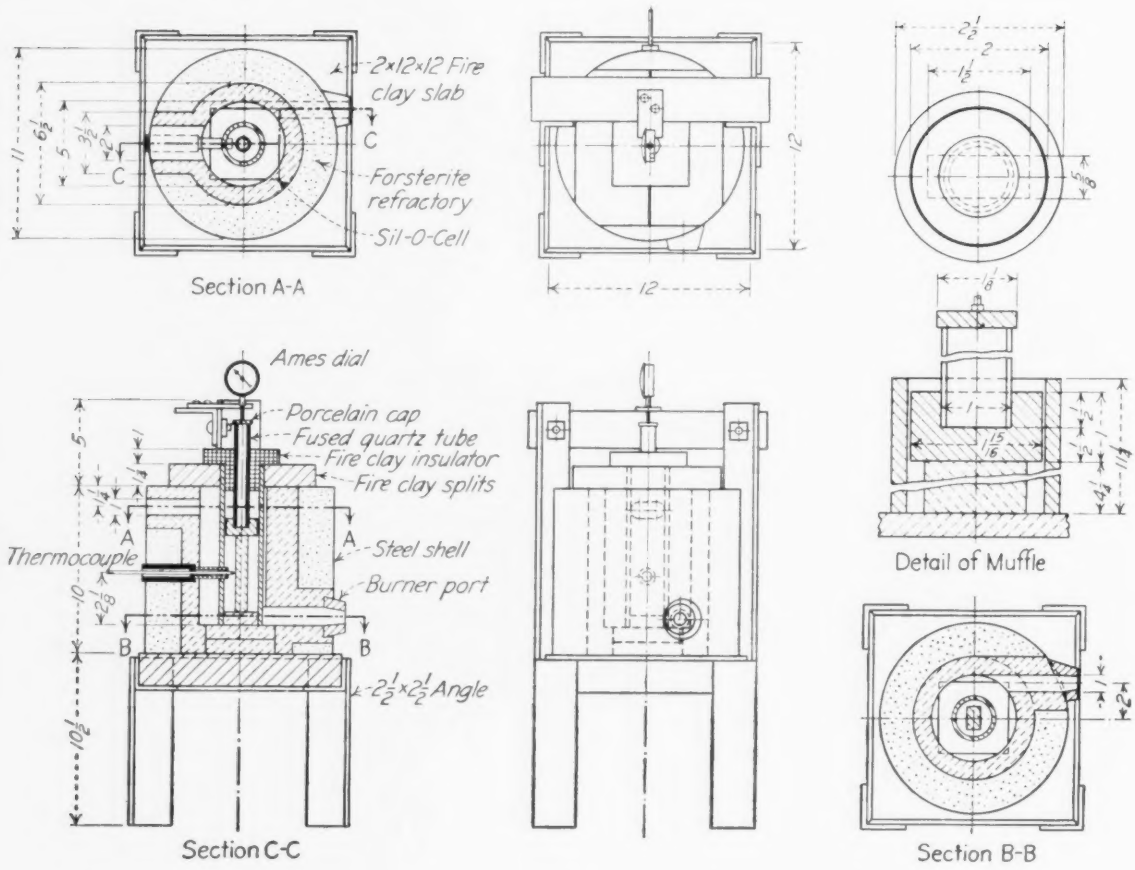


FIG. 1.

men of fused quartz, and another calibration was made at the end of each series. Two specimens were run on each grain size. Readings were taken 200°F apart from 400°F to 2200°F, intermediate points being obtained, when, in the judgment of the authors, they were desirable.

To determine the effect of the clay bond on the pyrophyllite, an expansion curve was obtained also on a specimen of the bond clay and on a specimen of finely ground pyrophyllite with no clay bond.

The expansion of the needles was determined by obtaining the volume of individual crystals, each weighing approximately 0.3 gram, fired and unfired, using the pycnometer method as outlined by Andrews. The percentage volume expansion was calculated from the volume differences and was determined only at 2200°F.

IV. Material Tested

The chemical compositions of the materials used are as follows:

	Needles	Radiated granular type	Ball clay
H_2O			
Ignition loss	5.37	4.32	12.50
SiO_2	65.70	70.26	47.00
Al_2O_3	28.32	24.94	37.83
Fe_2O_3	0.12	0.08	0.71
CaO	0.12	0.12	Trace
MgO			0.20
K_2O	0.06	0.13	0.10
Na_2O	0.36	0.31	0.20
TiO_2			1.20
Total	100.05	100.16	99.74

TABLE I
SPECIMENS FOR THERMAL EXPANSION DETERMINATIONS

Grain size (sieve no.)		Pyrophyllite (%)	Clay (%)
(passed)	(retained on)		
10	20	85	15
20	30	85	15
60	80	85	15
100	200	85	15
200	Pan	85	15
200	"	100	00
40	"	00	100

V. Results

The expansion of the needles of pyrophyllite from room temperature to 2200°F was deter-

mined to be 520% on a volume basis. The linear changes of the bond clay, when heated, are shown in Fig. 2. Figure 3 shows that the effect of the clay bond on the pyrophyllite was to reduce the expansion of the mixture, and the curves shown in Fig. 4 illustrate the effect of grain size on the expansion of pyrophyllite. It will be noticed that in all three the greatest expansion occurs between 1200° and 1600°F, which corresponds approximately to the range of greatest weight loss (Fig. 5). A peculiar feature of the curves (Fig. 4) is that as the size of grain decreases, the effect of further reduction in grain size is lessened. While the ratio of the particle sizes in *A* and *B* is practically the same as in *D* and *E*, the difference in expansion of *A* and *B* is great, while in *D* and *E* it is very small.

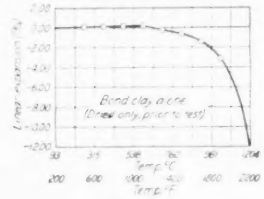


FIG. 2.

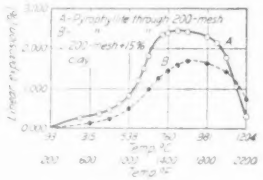


FIG. 3.

It was noted in these determinations that the rate of expansion is very slow between 1000°F and 1600°F in all grain sizes, approximately three hours being required at each intermediate temperature for expansion to cease. This can not be explained by assuming that the sample was slow in becoming uniformly heated. The expansion was constant at nearly all temperatures after 30 minutes.

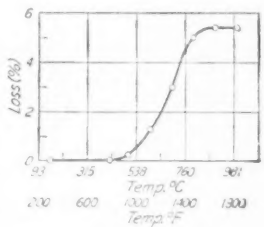


FIG. 5.

In connection with these conclusions, it is of interest to note some results obtained in other experiments by the authors on the same type of pyrophyllite. It was found that when pyrophyllite was ground and sized so that the largest grains ranged between 4- and 20-mesh and were bonded with clay, as was done in this investigation, the distribution of grain sizes was such as to give practically zero volume change when fired between cones 10 and 16.

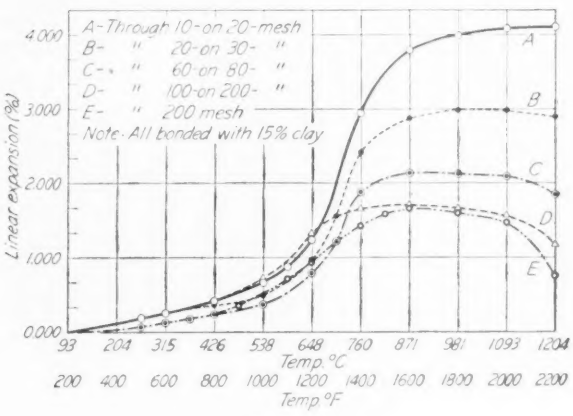


FIG. 4.

VI. Conclusions

The results obtained are principally of value in explaining the differences obtained in shrinkage determinations on bodies containing pyrophyllite and in showing that when finely ground, as in whiteware bodies, the expansion is not great. The following conclusions may safely be drawn:

(1) Pyrophyllite has a sudden expansion between dull red heat and 1600°F.

(2) After the expansion is complete, the material finer than 60-mesh undergoes shrinkage.

(3) The expansion of the pyrophyllite is indicated to be due to physical changes taking place during dehydration.

(4) The amount of expansion is dependent upon the size of the particles.

(5) Additions of clay tend to decrease and slow down both the expansion and the subsequent shrinkage of the pyrophyllite-clay mixtures.

(6) If needles of pyrophyllite are present in aggregates of macroscopic size, they will cause the body to crack upon firing.

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF NORTH CAROLINA, RALEIGH UNIT
RALEIGH, N. C.

THE EFFECT OF HEAT TREATMENT ON THE PHYSICAL PROPERTIES OF GLASS*

By J. T. Littleton

Abstract

Data are given showing that the physical properties of glass, when held at constant temperature, are not attained immediately at this temperature but that there is a lag and that this lag depends upon the viscosity of the glass. This effect is illustrated by showing time rates of change at constant temperatures of expansion coefficient, electrical conductivity, and viscosity. The change in expansion coefficient is shown to be particularly important when seals are made between two differing glasses or between glass and metal.

I. Introduction

This paper consists of a review of some of the new work relating to the effects of thermal treatment on the physical properties of glass and a brief discussion indicating wherein these findings may have some bearing on the properties of other ceramic materials. Glass is an important constituent of all ceramic articles and anything which affects the glassy portion of a ceramic body must necessarily affect the properties of such a body. It has been shown that melting conditions have no effect on the properties of a glass except as they affect its homogeneity or modify its composition by volatilization of some constituents or by a solution of the refractory. As glass cools, some component may crystallize. The amount of devitrification occurring, if any, depends upon the glass composition, the rate of cooling, and the temperature. Thus there are no general facts concerning devitrification applicable to all glass compositions, and devitrification phenomena, therefore, even though of considerable importance in ceramics, are not a part of this discussion.

When glass cools two general effects appear: one may be called a mass or volume effect and the other, a molecular effect. These effects are controlled by the heat treatment, and while they may occur simultaneously they bear no direct relationship to one another. The mass effect is that due to differential cooling, one portion of the body cooling at a different rate from another, thereby producing a stress between the two. This is the usual strain phenomenon. The general physical properties of the glass are not modified because of the stress in the glass, but where the glass is stretched or in tension its effective strength is lowered in proportion to the amount of tension. If such a strained piece of glass is broken it will be found that all particles of it are alike, having approximately the same density, refractive index, electrical conductivity, etc., so that the effect of strain is a purely elastic effect. But at the same time there is another effect produced by fast cooling in that the glass has a lower index of refraction, a lower density, etc., than the same glass when cooled slowly. This difference is due to a molecular effect and is caused by some lag in the adjustment of the molecules to their positions of equilibrium corresponding to the particular temperature. These two effects of strain and of equilibrium will be considered separately in more detail.

II. The Effect of Residual Strain

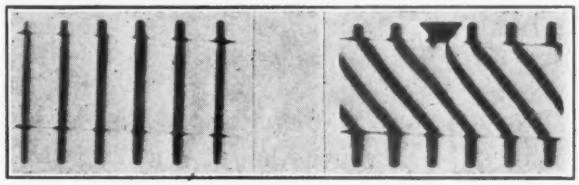
Before considering the effect of residual strain or internal stress, it is first desirable to discuss briefly the causes and origin of strain in glass. If strips of hot and cold metal be bolted together, there will be no stress in the system until the temperature of either component changes. If molten metal be poured on cold metal and should stick, there is no stress present until the molten metal freezes and starts to shrink. If two pieces of the same kind of metal be joined together while cold or hot, there will be no stress as long as the two are at the same temperature regardless of the previous heating cycles the pair may have gone through together, unless there has been a flowage or creep in one or the other.

Strain in glass is the result of a temperature gradient set up in glass while in a viscous state and maintained during cooling until all the glass has solidified. At that instant of solidification the glass may be free of stress, but since the glass is now a solid with temperature differences existing in its body, which later disappear as the temperatures become equalized, then at that time

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 30, 1936 (Ceramic Ware Firing Symposium).

there must be a permanent residual strain set up. The portion of the glass which was the hottest when the glass was completely solidified later cooled the most and therefore contracted the greatest amount. The contraction, however, was resisted by the adjacent initially cooler glass and it is this reaction which causes the strain. For

←Compression Tension→



(*a*) Compensator field showing annealed unstressed sample. (*b*) Annealed sample under externally applied bending stress.

FIG. 1.—Babinet strain pattern of annealed glass.

residual permanent strain to develop, it is necessary that the glass be viscous at the time the temperature gradient exists; otherwise the temperature differences will result only in elastic contraction or extension.

It is here that glass differs from porcelain or clayware. When glass gets hot it may be soft enough to yield to internal stresses while the clayware will not except as its glass portion yields. The flowage of this glass bond is not accompanied by a complete yield in the structure inasmuch as the solids present are held into some form of structural framework and this acts as a semi-rigid body. Such a body becomes more like a glass as the solid particles become smaller.

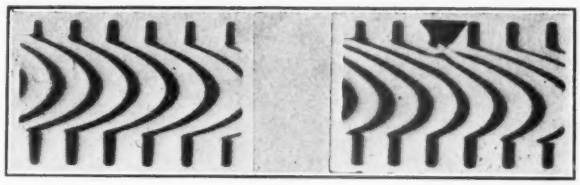
Summarizing briefly, glass acquires strain because it is viscous during a portion of its cooling, while if clay bodies acquire permanent strain by cooling from high temperatures it is due to a trace of viscous yield or to lack of uniformity through the clay. The harder fired portions, being more vitrified, shrink differently in cooling from the other portions; stresses, therefore, may be set up between them, just as there would be stress between two dissimilar glasses or metals welded together.

Fortunately strain in glass can be detected by a polariscope, and the stress may be measured by some form of strain compensator. If a slab of glass of rectangular cross-section be bent, the slab will be in tension on the convex side and in compression on the concave side, while the stress will be zero at the center. The stress changes uniformly from one surface to the other, and the stress diagram for such a system will be represented by a straight line. Figure 1 shows such an analysis made by the Babinet compensator. The displacement of the original Babinet line by the glass is proportional to the stress, and by measuring the displacement the stress may be evaluated.

If a glass plate, while in a viscous condition, be uniformly chilled on all faces, the surface becomes cooler than the interior and later, when the interior cools, it contracts with respect to the surface. This condition leads to a toughening action on the surface, which is in compression while the center is in tension. The so-called "toughened glass" is made in such a manner. The explanation of this toughening action is given in some detail by Littleton[1] and Littleton and Preston,[2] but the essentials can be readily explained by means of an optical analysis of the stress system using the Babinet compensator.

Such an analysis is shown in Fig. 2. If such a sample of glass be bent, the applied stress combined with the internal stress gives the resultant distribution as shown in Fig. 2. The effect of the initial strain is to neutralize a part of the load tension, the neutralized amount being exactly equal to the initial compression. The

←Compression Tension→



(*a*) Compensator field showing pattern of strained glass. (*b*) Strained sample under externally applied bending stress.

FIG 2.—Babinet pattern of strained glass.

load stresses can be computed when the load and dimensions of the piece under test are known. This load stress then may be combined with the initial stress in the glass as measured with the Babinet compensator and the resultant stresses

[1] J. T. Littleton, "Tensile Strength of Glass," *Phys. Rev.*, **22**, 510–16 (1923); *Ceram. Abs.*, **3** [3] 70 (1924).

[2] J. T. Littleton and F. W. Preston, "Theory of the Strength of Thermally Toughened Glass," *Jour. Soc. Glass Tech.*, **13** [52] 336–49 (1929); *Ceram. Abs.*, **9** [7] 513 (1930).

may be shown in a stress diagram. Figure 3 is a stress diagram of a piece of strained glass loaded until it broke. Owing to the initial stress present, the sample had a modulus of rupture of 17.8 kg./mm.^{2}, but if this initial stress had not been present it would have been only 4.6 kg./mm.^{2}

This shows that glass may be strengthened if properly strained. If the strains are not properly distributed, however, the glass may be weakened to the point that a tiny scratch in the surface will completely fracture the sample.

If the internal residual stresses be very great the glass will fracture into many small pieces as soon as a crack is started though it may require a large force to start such a crack. The familiar Prince Rupert drop is an example of this. The "Securit" glass windshield is an application of this principle. The glass is very strong, but when it

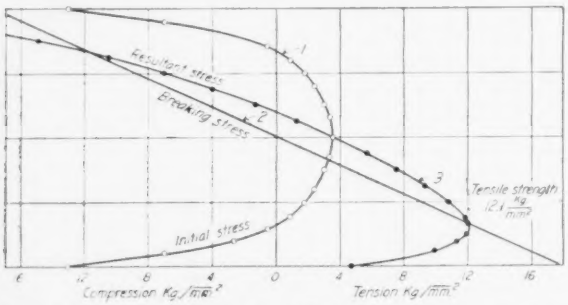


FIG. 3.—Stress diagram in chilled glass carrying bending load.

breaks it shatters into very small pieces minimizing danger from serious cuts.

This process, however, necessitates that all exposed surfaces of the glass be under compression. A fairly heavy-walled blown glass bulb may have its outer surface under compression and be so strong that one can use it to drive nails, and yet the inner surface may be under sufficient tension that a small scratch on this surface will cause the entire bulb to fly into many pieces.

This type of thermal treatment can not be applied to porcelain or clayware because such bodies do not become sufficiently viscous to yield or flow under thermal stresses at any period of their manufacture. A similar action, however, is obtained by a surface glaze when such a glaze has a smaller expansion coefficient than the under body. This gives a toughened surface, but the change in stress from the compression in the surface glaze to the tension in the under body is very abrupt rather than gradual as in the case of suddenly cooled glass, and the problem in porcelain ware is not so simple. The glaze weld to the porcelain body is more like a glass-metal seal.[3]

III. Molecular Effect

The physical properties of materials in general change markedly with temperature. If heated they expand and all of the physical properties, such as density, electrical and thermal conductivity, specific heat, and viscosity are affected. In the case of glass, however, it is interesting to note that these changes do not occur instantly but may take place over a considerable period of time. A metal, when heated, expands just as rapidly as it is heated and its physical properties are constant at any given temperature unless it may happen to be crystallizing. In the case of glass, however, the properties do not adjust themselves instantly to temperature. If a piece of glass be heated so suddenly that its temperature increases practically instantaneously, a certain amount of expansion will immediately take place, followed by a slow volumetric change. In cold glass, this later volumetric change is so slow that it would not be measurable in a million years. In very hot glass (glass that is fairly fluid), the change takes place so quickly that it is not observable. Somewhere in between these extremes, the changes are observable and are possibly of considerable practical importance in ceramic bodies. The glass in the course of time ceases to change and may be said to be stabilized. The stabilized properties are "frozen" into the glass. If glass should become stabilized at some upper temperature and be suddenly cooled, its viscosity is much lower than if it were slowly cooled, and at this lower temperature it gradually approaches some final value. The reverse is also true; that is, if it be stabilized at a low temperature and then heated rapidly to a somewhat higher temperature, the viscosity remains higher than if the glass were heated slowly, and it gradually decreases when the glass is held constant at this higher temperature until it becomes stabilized. Similar effects are found in the case of its other physical properties. Since the changes in electrical resistance, viscosity, and thermal-expansion coefficients are large, easily measured, and of some practical

[3] The stresses in such a seal are shown in Fig. 4 in a paper by J. T. Littleton, "Effect of Temperature Treatment on Glass-to-Metal Seals," *Jour. Amer. Ceram. Soc.*, **18** [8] 242 (1935).

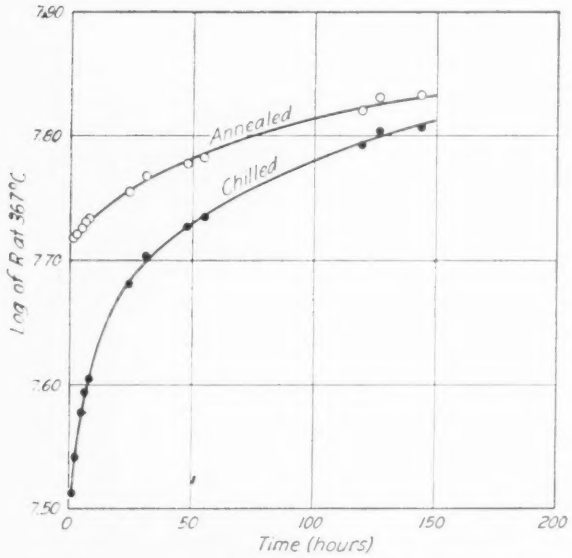


FIG. 4.—Resistance as a function of temperature.

significance, they will be discussed separately in more detail.

(1) Electrical Conductivity

It has been known for some time that poorly annealed glass has a higher electrical conductivity than well-annealed glass; in some cases the ratio of conductivities being as much as three to one. A curve between log R and $1/T$ (where R is the specific resistance of the glass and T is the absolute temperature) for some time was thought to be made up of two straight lines intersecting at a point. Littleton,[4] however, has shown that this curve depends upon the rate of heating and has its apparent form due to the tendency of the glass to change its state of stabilization as the temperature changes.

The change of resistance with time while at constant temperature is shown in Fig. 4. The data shown there are taken by the method described in another paper.[5] It is clear that the initial resistance value is dependent upon the previous heat treatment of the sample and that this value changes with time, finally becoming constant. The annealed and chilled samples should attain the same final value.

Curves[5] for chilled, annealed, and stabilized glass show that the resistance may increase or decrease with time, depending upon whether the glasses were previously stabilized at a temperature above or below the testing temperature. It is apparent that the resistance of the glass below a certain temperature depends upon the previous heat treatment of the sample. In the case of the chilled and annealed samples, the measurements were made with the temperature increasing at the rate of $^1/_2$°C per minute. Below 400°C the annealed glass has a resistance less than the stabilized value, because it is in a state of stabilization corresponding to some higher temperature. The glassy state changes during the measurement so that when it reaches 400°C it is stabilized at this temperature. When this temperature has been exceeded, the glass tends to retain its lower temperature resistance values until 450°C is reached. From this point upward the stabilization state of the glass changes about as rapidly as the temperature changes. The case for the chilled glass is similar, but as it was initially in a state of stabilization corresponding to a higher temperature than that of the annealed glass, it required a higher temperature before intersecting the stabilized curve.

(2) Viscosity

Since the viscosity of glasses changes very rapidly with temperature, doubling every six to eight degrees drop in temperature when the glass is near the strain-point temperature, it would be expected that viscosity would be sensitive to any specific volume changes. This is the case as is shown in Fig. 5. The lower curve was obtained with an unannealed freshly drawn fiber in which the state of stabilization corresponds to that of some high temperature, inasmuch as the small

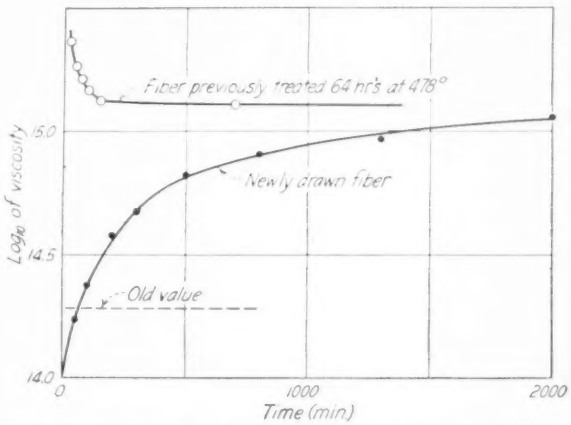


FIG. 5.—Viscosity of a typical glass as a function of time at constant temperature.

[4] J. T. Littleton, "Critical Temperatures in Silicate Glasses," *Ind. Eng. Chem.*, **25** [7] 748–55 (1933); *Ceram. Abs.*, **12** [10–11] 360 (1933).

[5] J. T. Littleton and W. L. Wetmore, "Electrical Conductivity of Glass in the Annealing Zone as a Function of Time and Temperature," *Jour. Amer. Ceram. Soc.* **19** [9] 243–45 (1936) (see Fig. 5, p. 245).

fiber used in the measurement cooled very quickly. The upper curve was obtained with a fiber which had been stabilized at a temperature of 478°C. The measurements were made at 487°C, and this fiber therefore was initially hard, but it gradually softened when maintained at a constant temperature above its original stabilization temperature. As the curve shows, it took about 1000 minutes to attain its final stabilized value at the higher temperature. These curves are on a logarithmetic scale, which means that the viscosity at 487°C of the fiber of glass previously heat treated at 478°C is seventy times that of an untreated sample of the same glass.

This difference is very striking, but much greater differences can be obtained where forced cooling or a lower temperature of stabilization is applied to the fiber.

(3) Thermal Expansion Coefficient

When a glass is heated it expands. Attending this purely thermal expansion change, there is a change in specific volume. The volume change will take place at a constant temperature while, by definition of thermal expansion coefficient, there can be no expansion with temperature unless the temperature changes. At low temperatures, however, the specific volume change is so infinitely slow that it can not possibly be detected and may be neglected. But at some higher temperature, the glass undergoes a measurable change in volume with time on account of the stabilization process. The temperature at which this change becomes measurable depends entirely upon the previous state of stabilization and the refinements of the measuring equipment. At high temperatures the molecules of the glass are more dispersed than at low temperatures, and when the glass is quickly chilled these molecules can not instantly get to their final equilibrium position because of the viscous nature of the glass; hence they are frozen into a somewhat rarified configuration. This phenomenon is sometimes explained as a state of molecular aggregation, which is frozen in the glass by sudden cooling.

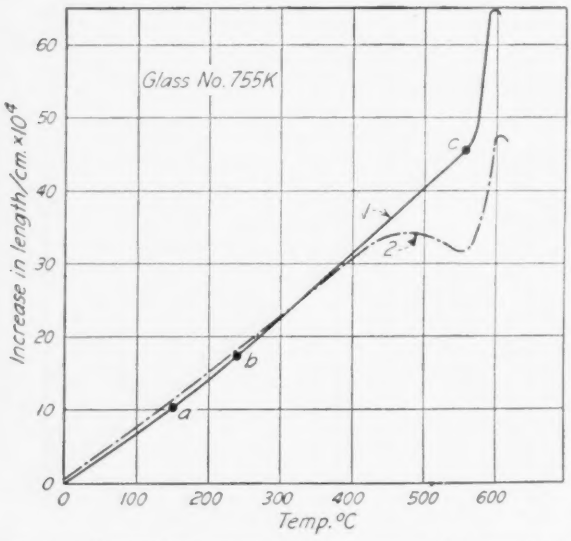


FIG. 6.—Expansion curves of glass: curve (1) annealed glass; curve (2) unannealed glass.

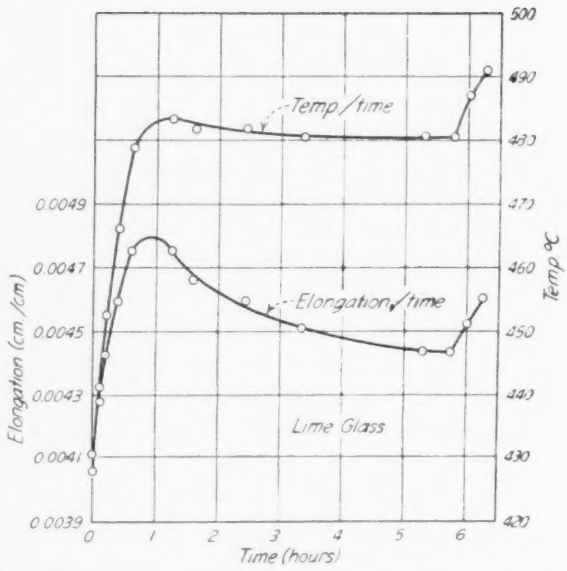


FIG. 7.—Change of length with time at constant temperature.

Characteristic expansion curves of annealed and unannealed glasses are shown in Fig. 6. It can be seen from the curve on the unannealed glass that at about 350°C a volume change begins to become evident. But the temperature is rising during the measurements and the glass is undergoing a purely thermal dilatation. The stabilization change in this case causes a contraction so the glass appears to expand at a slower and slower rate until it finally actually contracts more than it expands. If at any time the temperature had been held constant, the glass would have continued to contract until it was fully stabilized (see Fig. 7). The glass in this case was cooled from 520°C sufficiently slowly to be well annealed but fast enough to retain a state of stabilization corresponding to some temperature fairly near 520° C. The sample was then heated to 425°C and elongation observations were made as the temperature

was increased to 483°C, where an attempt was made to hold the temperature constant. Actually it cooled three degrees in the next five hours, but this is of little consequence. At this supposedly constant temperature, the glass contracted and the contraction continued for about five hours. At this time the glass was almost stabilized and contraction had practically ceased.

This means that for about 150° below the annealing point of a glass there is no constant and definite expansivity. There are always two effects, one a purely thermal dilatation and the other a volume change whose magnitude depends upon the time, temperature, and previous thermal history of the glass. Ordinarily glasses are not used at temperatures where this volume change with time becomes observable, but if it should be all parts of the glass will be affected alike and the properties of the glass remain sufficiently near those of the original glass for all practical purposes. In cases, however, where a glass is bonded to a different material, such as the glass in porcelain bodies or glass-to-metal seals, only the glass portion can change and this effect is certain to be of considerable importance.

It has been previously shown how heat treatment affects the stress set up in a seal between the glass used and platinum.[3] The seal can be changed from a high tension to a compression at the glass-metal interface by the proper heat treatment. Something similar to this must occur in the glass in the body of clayware, in the glazes on such bodies, and in enamel glazes on metals. The possible importance of these effects should not be overlooked.

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THE SPRAY-DRYING PROCESS: SOME POSSIBLE APPLICATIONS TO CERAMICS*

By Robert Twells

Abstract

The process of dewatering liquids by spray drying is assuming increasing importance in the chemical industries. Solutions, emulsions, solid suspensions, and their combinations can be dried quickly, cheaply, and under accurate control. The spray-dried particles tend to be granular and nearly spherical in shape; the product is a dense free flowing powder which is especially well adapted to automatic handling, packaging, and dry pressing into shapes. Ceramic materials of low bulk density can be prepared in the liquid state and spray dried to a dense granular powder which is easier to handle and freer from dust than the same materials prepared by dry grinding.

I. Introduction

The spray-drying process consists of atomizing the slip directly into a stream of heated air. The cost and the time consumed are low and the process is automatic, requiring little labor.

Most of the materials being spray dried are either true solutions or combinations of solution with emulsion or solid suspension, which can not be dewatered readily by filter-pressing or settling because the soluble matter would be carried away in the solvent. The spray-type method of evaporation is effective because of the high surface area of the little drops of liquid while exposed to the heated air, making it especially suitable to drying combinations of solid suspension and solution.

A spray drier will produce dry granular particles without dust.[1] It will reduce the volume of materials which would ordinarily be fluffy and difficult to store. The particle size is controlled chiefly by the mechanical and thermal conditions under which the particular spray drier operates. In general, the bulk density of the spray-dried product is increased as the water content of the original liquid is decreased.

II. Spray Drying Ceramic Slips

The various methods used in spray drying have been thoroughly covered by Reveall[2] and

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[1] A small percentage of organic binder, such as dextrine or gum arabic, added to the liquid will sometimes toughen the "skin" of the particles and tend to prevent them from breaking down in handling.

[2] J. A. Reveall, "A Recent Development in Spray Drying," *Chem. & Ind.*, **46**, 925–30, 951–57 (1927).

by Wilson, Page, and Cartwright.[3] The three methods commonly used in spray drying are (1) high-pressure liquid atomization, (2) compressed-air atomization, and (3) centrifugal atomization.

(1) High-Pressure Liquid Atomization

High-pressure atomization has been used for spray drying a Florida kaolin, but in the case of ceramic materials, which are abrasive, this method would be impractical. In one instance, with a very abrasive material, the pump valves and jet orifices were eroded in less than 15 minutes of operation.

(2) Compressed-Air Atomization

Compressed-air atomization is less commonly used in spray drying. The use of compressed air makes the operation somewhat more expensive and requires some type of separator to remove the sprayed particles from the air stream. Nozzle wear and clogging are less serious problems than with the high-pressure liquid method. Compressed-air atomization is well adapted to the spray drying of small lots of material and the product is satisfactory in most cases for experimental purposes.

(3) Centrifugal Atomization

Centrifugal atomization is the most practical production method for spray drying ceramic slips. Slinger speeds from 1000 to 18,000 r.p.m. have been reported. A slinger directly connected to a motor of 3450 r.p.m. offers the fewest mechanical difficulties and can be made to deliver a good yield with a minimum of wear on the slinger.

(4) Method of Heat Application

Ceramic slips are most economically dried with a direct open flame or by the use of waste heat from kilns.

The refining of clays by washing, settling, and spray drying has been tried by several experimenters, and used by at least one company for a number of years.[4]

Ceramic nonplastic raw materials, such as feldspar, flint, whiting, and talc, dry ground to a fine powder for shipment and use, have a low bulk density and a high angle of repose, properties which make them bulky, dusty, and often difficult to handle and store. Instead, these materials might be wet ground to a slip and spray dried to a granular powder which could be bagged or handled in bulk with less difficulty.

Soluble ceramic materials are difficult to handle and some give off an irritating dust. These materials could be spray dried and supplied in granular form to avoid these difficulties.

Mixtures of soluble and insoluble materials for calcines or frits can not be prepared wet by ordinary methods. By utilizing a spray drier, such materials could be wet ground and dried to a homogeneous granular powder which would be simple to calcine or feed to a frit furnace.

The preparation of dried glazes or enamels for shipment or for the dry process of application to cast iron are other possible uses for the spray drier.

The ordinary method of preparing a casting slip involves the preparation of a dilute slip, followed by filter-pressing and reblunging the cakes into a concentrated slip. The spray drier offers the possibility of accomplishing these steps in one operation.

Ceramic bodies have been spray dried and used successfully for dry pressing ceramic shapes. The ware which has been dry pressed from a spray-dried body is denser and more uniform than ordinary dry-pressed porcelain because the granular particles are especially suitable for the process.

[3] Hewitt Wilson, G. A. Page, and V. S. Cartwright, "Dewatering Clay Suspensions by Spray Evaporation," *Bur. Mines Rept. of Investigations*, No. 3248 (1934); *Ceram. Abs.*, **14** [4] 103 (1935).

[4] See reference footnote 3, p. 38 of the report.

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KYANITE OPERATIONS OF CELO MINES, INCORPORATED*

By V. L. Mattson

I. Introduction

The production of kyanite at the property of Celo Mines near Burnsville, North Carolina, has involved some problems that are different from those usually encountered in the development of a ceramic raw material. Normally, ceramic raw-material preparation consists of removing a small amount of impurity from a bulk of relatively pure material. With kyanite, the valuable mineral is in a decided minority and must be concentrated from a uniform but low-grade ore.

II. Ore Deposit

The principal ore deposit of Celo Mines is a huge lens of kyanitic gneiss which has been definitely outlined by systematic sampling. At one point a vertical face of more than one hundred and fifty feet is exposed. The tremendous tonnage indicated and the remarkable uniformity of the ore make speculation as to its origin an interesting problem. Authorities on the pre-Cambrian formations of western North Carolina are of the opinion that the kyanite crystals were formed through secondary enrichment as high aluminous pegmatitic magmas were injected into the folded sediments of the area. The mineral associations are rather unusual. In addition to kyanite, the gneiss contains quartz, muscovite, and biotite as major constituents. The minor minerals present are garnet, albitic feldspar, apatite, beryl, and a variety of sulfides. A polished section of representative ore has shown, in addition to pyrite, the following sulfides: pyrrhotite, chalcopyrite, galena, sphalerite, bornite, and chalcocite. The titanium minerals appear to be completely missing from this rather complex ore.

It is believed that kyanite has replaced some of the original quartz in the gneiss. This replacement process seems to have been confined to a definite period, as repeated examinations of polished sections of the ore seldom reveal crystals of kyanite with quartz inclusions.

The uniform quality of the ore has made the mining problem simple. A series of 20-foot benches have been blasted parallel to the strike of the deposit. After secondary blasting, the ore is collected by means of a drag scraper to a loading platform. From this platform the ore is loaded by gravity into 8-ton side dump cars. A 36-inch gage tramway connects the mine with the concentrating plant.

III. Concentration

The mine cars dump directly into an 80-ton hopper which is immediately above the primary crusher. Primary breaking is done in a 15- by 24-jaw crusher which reduces the ore to 4 inches. A 10- by 22-crusher reduces this product to 2 inches or less. A belt conveyer transports the crushed ore to a 350-ton storage bin.

The crushed ore, after passing over a scalping screen to remove the undersize, is fed to a Jeffrey hammer mill. This mill, which is operated at 1800 r.p.m. with special hammers and without grate bars, produces a disintegration of the ore with practically no grinding of the individual mineral crystals. The result is that the kyanite particles, which are the largest individual crystals in the ore, are largely concentrated in the coarser screen fractions of the hammermill product. Nearly 70% of the kyanite in the mill feed is retained on a 28-mesh screen, and about 95% of the kyanite in the feed is retained on a 48-

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Materials and Equipment Division).

mesh screen. This screen concentration of values makes possible the elimination of about one-third of the weight of the original ore with little loss of valuable product.

For convenience of further treatment, the ore at this point is graded into two sizes as follows: −16- + 28-mesh and −28- +48- mesh. Surge bins for the products provide uniform feed to the concentrating operations that follow. From the surge bin the −16- + 28-mesh ore passes over an induction-type magnetic separator which, in addition to abraded iron, removes the following minerals: sulfides, garnet, biotite, and a part of the muscovite. The nonmagnetic product from this separation consists principally of quartz, kyanite, and small amounts of feldspar and muscovite. This material forms the feed to a pneumatic concentrating table which effects a clean separation between the kyanite and other minerals present.

The − 28- + 48-mesh ore is given a preliminary tabling before passing over the magnetic separator. A large amount of mica is thus removed and the capacity of the magnetic separator is correspondingly increased. The nonmagnetic concentrate is then given the same tabling treatment as described for the coarse fraction.

The concentrate from the pneumatic table is sampled and sacked as a finished product. When finer grain sizes are desired, this product is reground in a Silex-lined pebble mill operating in circuit with a Gayco centrifugal separator and a Rotex screen.

A semicommercial calcining unit has been installed to produce mullite from the kyanite concentrate. A small oil-fired rotary kiln is used for calcining. Samples are taken from each 100-pound bag of kyanite as it is filled, and specific gravity determinations are made on each sample.

Splits from these samples are saved, and once each shift a heavy liquid mineralogical determination is made to check the specific gravity results.

The garnet in the ore is recovered as a high-grade concentrate. This grain is finding a market as an abrasive for use in sandblast machines at monumental stone plants. Progress is also being made in the development of a salable mica by-product.

Celo Mines, Incorporated
Burnsville, North Carolina

ACTIVITIES OF THE SOCIETY

DIVISION SUMMER MEETINGS

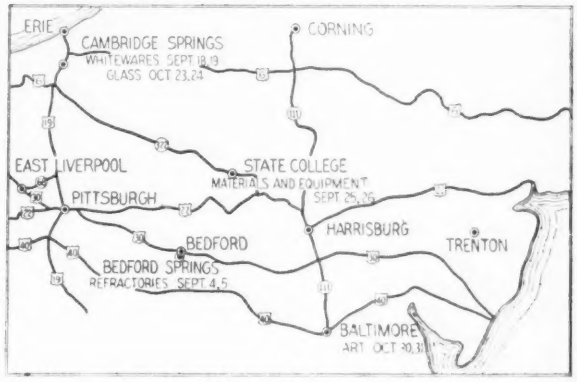
WHITE WARES DIVISION PROGRAM

Hotel Bartlett, Cambridge Springs, Pa., September 18 to 19, 1936

The program of technical papers for the Summer Meeting of the White Wares Division is announced and all members of the Society interested in the discussion topics are invited to attend this meeting. Reservations may be made by writing directly to the Hotel Bartlett, Cambridge Springs, Pa.

See map showing the location of Cambridge Springs, with marked auto routes.

Morning sessions will be held on Friday and Saturday, from 9:30 A.M. to 12:30 P.M., allowing the two afternoons for golf and informal visiting.



Technical Discussion Program and Topic Leaders

The *numerals in parentheses* refer to the topics outlined in March, 1936, issue of *The Bulletin*, page 95 on "Proposed Symposium on Body Preparation."

I. (1) Physical and Chemical Properties of Body Materials; Specifications Governing Their Purchase; Origin, and Mining.
By R. A. Snyder, Westinghouse Electric & Mfg. Co., Derry, Pa.

II. (2) Chemical Composition of the Water and Its Effect.
By James R. Beam, Universal Sanitary Mfg. Co., New Castle, Pa.

III. (3) Effect of the Soluble Salts from Clay on the Dispersion Process.
(10) Control of the Body Slip by Determination of Density and Fluidity; Value of p_H Determination and Possible Use of Dispersing Agents.
By Tom Falknor, Edgar Bros. Co., 126 W. Tulane Rd., Columbus, Ohio.

IV. (5) Moisture Determination and Correction.
(6) Types of Blungers; Power Consumption.
By Elmo H. Lintz, Taylor, Smith, & Taylor Co., Chester, W. Va.

V. (14) Magnetic Separators.
By Ross Buchanon, Mayer China Co., Beaver Falls, Pa.

VI. (4) Ball-Milling *vs.* Blunging.
(15) Pumping: Use of Centrifugal, Plunger, and Diaphragm Pumps, Compressed Air, and Combination Systems; Power Consumption.
(16) Pipe Material: Sizes and Bends; Corrosion and Plugging.
By Martin R. Hornung, Shenango Pottery Co., New Castle, Pa.

VII. (26) Comparison between the English Slop or Wet Method of Slip Preparation and the American Dry System; Possible Combination of the Two.
By J. Palin Thorely, Carrollton Pottery Co., Carrollton, Ohio.

VIII. (7) Preliminary Disintegration of the Clays.
By R. C. Meeker, Kentucky-Tennessee Clay Co., Alliance, Ohio.

IX. (18) Filter-Pressing Methods: Periodic and Continuous Filter Presses.
By Edwin M. Rupp, Square D Co., Peru, Indiana

X. (20) Filter-Press Sacks and Their Treatment.
By G. A. Quay, J. E. Quay & Co., East Palestine, Ohio

XI. (17) De-Airing of Slip.
(21) Aging of Body.
(22) De-Airing of Body.
(23) Effect of Temperature in the Several Processes.
(24) Pugging by Horizontal, Vertical, and De-Airing Pug Mills; General Design of Pug Mills; Possible Use of Kneading Machines.
(25) Pug-Mill Nozzles: Straight, Right-Angle, Lubricated, Rubber-Lined; Possible Adaptation of Electrolubrication.
By Grover W. Lapp, Lapp Insulator Co., Leroy, N. Y.

XII. (27) Methods of Body Storage and Aging Cellars.
(28) Means of Maintaining Constant Water Content in Press Cakes and Pugged Clay.
(30) Control of Consistency of Pugged Body.
By Frank Cermak, General Electric Co., Schenectady, N. Y.

—JAMES W. HEPPLEWHITE,
Summer Meeting Program Chairman, White Wares Division

MATERIALS AND EQUIPMENT DIVISION JOINT MEETING WITH THE INDUSTRIAL MINERALS DIVISION OF THE A.I.M.M.E.

State College, Pa., September 24 to 26

Thursday, September 24

Meet first at the Bell Mine, American Lime and Stone Co., Bellefonte, Pa., at 2 P.M. for inspection of this unique, well-planned underground limestone operation. Bellefonte is on Route 220. Meet at Nittany Lion Inn, State College, Pa., in late afternoon for registration and general get-together.

Committee meetings will be held on Thursday evening.

Friday, September 25

Mining Session

9:30 A.M.:

ROSS PURDY AND OLIVER BOWLES, *Chairmen*

(1) "A Modern Ball Clay Operation" by Richard Bell
(2) "Clay Mining Methods" by E. J. Lintner
(3) "The Wire Saw as a Tool for Cutting Slate and Building Stone" by Oliver Bowles
(4) "Mining Practice of the Bell-Mine Limestone Mine of the American Lime and Stone Company" by S. M. Shallcross
(5) "Limestone Sand" by A. T. Goldbeck

Beneficiation Session

2:00 P.M.

H. B. DUBOIS AND PAUL M. TYLER, *Chairmen*

(1) "Raw Materials Requirements in Whiteware and Glass Industries" by E. H. Fritz
(2) "Limestone Beneficiation" by B. L. Miller (lantern slides and moving picture)
(3) "Flotation as a Method of Beneficiating Clays" by M. I. Shaw

Informal Banquet

7:00 P.M.

Dean E. Steidle of the School of Mineral Industries will preside.

Short addresses followed by entertainment.

Saturday, September 26

Industrial Minerals

9:00 A.M.

H. RIES AND J. R. THOENEN, *Chairmen*

(1) "Industrial Mineral Education" by C. S. Crouse
(2) "California Ceramic Materials Other Than Clay" by B. M. Burchfiel
(3) "Gypsum Industry of the Grand Rapids, Mich., District" by A. A. Mathews

Beneficiation

9:30 A.M.

C. A. BONINE AND F. C. FLINT, *Chairmen*

(1) "Milling and Classification of Feldspar" by V. V. Kelsey
(2) "Magnetic Separation" by G. W. Jarman and S. G. Frantz
(3) "Air Separation of Minerals" by R. R. Slaymaker
(4) "The Kyanite Industry of Georgia" by Richard W. Smith

General Information

For those who are visiting State College for the first time the following general information may be helpful.

Location

The town of State College is located in the geographical center of Pennsylvania at the intersection of Highways 45 and 322. It is an easy drive from such outlying points as New York, Buffalo, Cleveland, Columbus, Washington, and Philadelphia. Bus-line schedules from Lock Haven, Bellefonte, Lewistown, or Tyrone should be checked with railroad schedules as there are no direct train connections to State College.

Headquarters

Headquarters will be maintained at the Nittany Lion Inn. The Inn, on Highway 322, is in a grove of trees on the Penn State Campus, with the athletic field on the East, the Gymnasium on the South, and an excellent golf course on the West. Listed rates, single, $3.00 to $5.00 and double, $5.00 to $9.00.

The rates of the State College Hotel are listed at $1.50 to $3.00 single and $3.00 to $5.00 double. In addition there are many private homes where guests may be accommodated at reasonable rates. Bring your family and enjoy the beauties and coolness of the mountains during these fall days. Those of high-school age will enjoy the college atmosphere.

Mail and telegrams should be addressed to the A.I.M.-M.E. or the American Ceramic Society at the Nittany Lion Inn, State College, Pennsylvania.

The registration desk will be opened at the Inn on Tuesday evening. Please register promptly on arrival for yourself and guests. When you register, please ask for your mail and get your ticket for the dinner.

The Women's Auxiliary will maintain a separate registration desk for the ladies. Provisions are being made for their entertainment.

The golf course is but a few steps from the Nittany Lion Inn. It will be open to all those who wish to enjoy its beauty and wonderfully maintained greens. Many excellent tennis courts are available at convenient locations for those who bring their rackets with them.

Meetings

The meetings will be held in the Mineral Industries Building, in which is located an excellent exhibit of industrial models, fossils, Indian relics, and charts. Of particular interest is the excellent exhibit of oil paintings depicting the mineral industries. The charts will show the location of the old charcoal furnaces and iron-ore pits which were so numerous in the vicinity of the College decades ago. The largest fossil footprint so far discovered in America is in the museum on the third floor.

The committee on local arrangements consists of C. A. Bonine, Dept. of Geology, Chairman; Wm. R. Chedsey, Dept. of Mining and Geophysics; and N. W. Taylor, Dept. of Ceramics. The entertainment for the ladies will be arranged by a committee under the leadership of Mrs. Edward Steidle.

DIVISION SUMMER MEETINGS

Refractories Subject: "Checker Brick and Regenerators"	Bedford Springs, Pa. Bedford Springs Hotel	September 3–5
White Wares Symposium: "Preparation of Whiteware Bodies to Secure Uniformity"	Cambridge Springs, Pa. Hotel Bartlett	September 18–19
Materials and Equipment Symposium: "Beneficiation of Ceramic Materials by Flotation	State College, Pa. Joint Meeting with the Industrial Minerals Div., A.I.M.M.E.	September 25–26
Glass Review of Second International Congress on Glass Papers and Reports	Cambridge Springs, Pa. Hotel Riverside	October 23–24
Art Subject to be announced later	Baltimore, Md.	October 30–31

GET ON BOARD GOOD SHIP CERAMICS

One hundred and fourteen (114) more persons than were embarked on January 1 are sailing on good ship Ceramics on Progress River with full fares paid. This is an average of nearly fifteen per month. This means that if *YOU* keep up this average *YOU* will sell this opportunity to sixty more persons, making a net total of more than fourteen hundred (1400) persons fully paid in 1936.

Do not count on those thirty-six (36) whose fares are deferred. If they can pay they will. They are in earnest and fully intend to make the ship in good standing.

But how about that loss of five Corporations? You can make up this loss if you will.

MEMBERSHIP STATUS

Date of Record	Members Paid: Personal	Members Paid: Corporation	Deferred	Subscriptions	Monthly sales	Total circulation
December 31, 1935	1248	187	26	488	225	2174
August 20, 1936	1352	182	36	490	200	2260

MEMBERSHIP SOLICITATION

You who are now personal members of the American Ceramic Society do not need to be told of its benefits and help to you personally and to your Company. We are sure you would like to see your Company join the American Ceramic Society as a Corporation Member. We know that you would like to see the work of the Society advanced because of the additional help it would bring to you. The Society can give service only as it gets funds. The $25.00 membership fee is nominal, but together with the contributions of other companies it can do a great work.

Will you make a personal follow-up of this appeal to your Company officers?

Incidentally, have you a technical assistant or foreman who should be a member? Why not ask him to join today?

—ROBERT TWELLS, *Chairman, Membership Committee, White Wares Division*

ONE MEMBER IS IMPRESSED

As I have thumbed through them, I am very much impressed with the fact that continuously as both *The Bulletin* and the *Journal* come to me I am reminded of the constant increase in quality. This applies both to the quality of the articles themselves which the members are putting in and to the make-up, ease of reading, and good appearance of the three publications.

Another Testimony

The Journal, Ceramic Abstracts, and *The Bulletin of the American Ceramic Society* are, it seems to me, increasing in their value and interest. This is creditable, in part at least, to my increased ability and desire to read the articles and certainly to the most attractive and condensed form of their presentation.

ART DIVISION MEMBERSHIP COMMITTEE REPORT*

C. C. Engle, Chairman of the Membership Committee of the Art Division, presents the following report of the activities and accomplishments of his Committee since its organization in 1935. In this report, he requests the active coöperation of all members of the Society. Any information which is available may be sent directly to C. C. Engle, 101 Oakland Street, Trenton, N. J.

Requests Names of Ceramic Art Workers

At the Annual Meeting of the Society at Buffalo, N. Y., in 1935, a rather ambitious reorganization program was undertaken for the Art Division. It was felt that first of all a list of all persons interested in any phase of ceramic art should be made available. The undersigned undertook to perform this task. During 1935, with the aid of the Committee of about 30 members, approximately 800 names were secured. During the first half of 1936, approximately 250 additional names have been added to the list. We are attempting to include as far as possible *all persons engaged in any phase of ceramic art*, that is, persons engaged in the commercial phase of the industry, teachers, crafts people, collectors, etc.

It would be greatly appreciated if members of the Society would contact their local Boards of Education, schools, colleges, universities, or State Boards of Education and thereby secure the names of those engaged within the school systems in ceramic work. I have found that it is difficult and in some cases impossible to secure this information by letter.

Your help will be thankfully received.

—C. C. Engle

* Received August 22, 1936.

THE NAMES OF CERAMIC COÖPERATORS WILL BE PUBLISHED

The Society's roster of coöperators will be published in the October issue of *The Bulletin*. This roster will contain the names of those whose membership fees have been paid.

Activities of the American Ceramic Society are your opportunities. Your participation and coöperation will mean self-education. For continued study in your vocation directly as well as in parallel ceramic fields, there is no opportunity more effective than the activities of this Society. The larger the Society's financial resources, the larger will be your opportunities.

This "Roster Issue" in October will provide an excellent medium for sales messages regarding materials and equipment usable in ceramic industries.

Member coöperators will enlarge their opportunities for continuing education by securing Personal and Corporation members and by selling space to those who are not now using *The Bulletin* for sales message purposes.

Space	Number of Insertions 1	3	6	12
Full Page	$60.00	$54.00	$48.00	$40.00
Half Page	33.00	30.00	27.00	24.00
Quarter Page	18.00	16.50	15.00	13.50
Eighth Page	9.75	9.00	8.25	7.50

ROSTER CHANGES DURING AUGUST*

Personal

Baker, Julius, 563 Stanley Ave., Columbus, Ohio. (Dayton, Ohio)

Dietrich, Waldemar F., Sacramento Junior College, Sacramento, Calif. (Rollo, Mo.)

Fisk, Henry G., Calaveras Cement Co., San Andreas, Calif. (Gary, Ind.)

Hoh, Shai-Kwong, Lingnan University, Canton, China. (New York, N. Y.)

Jones, Clifford, Messrs. Liptak Furnace Arches Ltd., Bridge Works, Broadheath, Altrincham, Cheshire, England. (Liverpool, England)

Jording, Harold, Frigidaire Corporation, Dayton, Ohio. (Ohio State Univ.)

Moulton, D. A., 316 Madison Ave., Evansville, Ind. (Ames, Iowa)

Munroe, Helen B., North Chatham, Mass. (Durham, N. H.)

Newcomb, Rexford, Jr., 243 Waltham St., Calumet City, Ill. (Univ. of Illinois)

Parsons, Joseph R., 1253 Diversey Parkway, Chicago, Ill. (Wellsville, Mo.)

Ricker, Richard W., Vitrolite Division, Libbey-Owens-Ford Glass Co., Parkersburg, W. Va. (Toledo, Ohio)

Robinson, G. R., 661 Cassingham Rd., Columbus, Ohio. (Zanesville, Ohio)

Thomas, Robert R., Jr., Box 203, R. 4, East St. Louis, Ill. (Flint, Mich.)

Voorhies, James A., 1001 Morrell Ave., Connellsville, Pa. (Clarksburg, W. Va.)

White, Milo A., Jr., 311 E. Main St., Fremont, Mich. (New Brunswick, N. J.)

Willson, B. W., R. 1, Zillah, Wash. (Kankakee, Ill.)

* Address in parentheses is the old address.

SOCIETY MEMBERS IN ENGLAND

On July 12, 1936, Louis Navias, General Electric Company, Schenectady, New York, sent the following note, descriptive of the "lighter" moments of the visit of the American glass technologists attending the Second International Congress on Glass.

"Enclosed is a snap of Hettinger and 'Hos,' which I took on the *S. S. Scythia*. They are obviously indulging in their hobby of camera examining.

"Het" and "Hos" on Steamship Scythia

"This brings up a very definite angle. 'Hos' had an expensive 'light-meter' which he used before taking pictures. 'Het' pooh-poohed the idea of a light-meter,

and took many fine pictures straight off. In the verbal battles between us on the subject, I suggested that 'Het' use a different system of light-units called the 'Hettinger,' so that an exposure of $^1/_{10}$ Hettinger was adequate for bright sunlight, and so on. At the Glass Congress, 'Het' was in great evidence with his camera and became quite well known to the foreign delegations, at various informal camera exchanges, and photo reviews. I proposed to these members that the only definite worth while piece of work of the Congress was the establishment of an international unit of light for ardent amateur photographers, namely, *the Hettinger*. The foreigners and visitors had plenty of fun for 'Het' was only slightly embarrassed.

"We have had two very crowded weeks. We have had plenty of technical sessions, plenty of speeches in English French, and German, and plenty of plant trips and side trips in the country. We have been overwhelmed with attentions and kindness and feel well disposed to all these people. Professor Turner, Mr. Dudding, Mr. Marchand, and many others were always on hand to help. Hospitality at plants could not have been better. It will take time to digest the technical material presented here. Kind regards to all in the office."

—Louis Navias

NECROLOGY

H. B. McMILLEN

Harry McMillen died of acute leukemia June 19, 1936, at his home in Los Angeles. He was a member of the American Ceramic Society for nearly thirty years.

Mr. McMillen was born in Pittsburgh, Pa., but moved with his parents to Macomb, Illinois, when a young boy. After completing the grade-school course, he obtained work in the Buckeye Pottery and soon was their best "thrower," turning up on the wheel large and complicated shaped stoneware pieces.

In 1903, he came to Ohio State University where he was coached through the two-year course in Ceramic Engineering, receiving a certificate in 1905. After two years spent in ceramic research in Idaho and Canada, he returned to Macomb as superintendent of the Western Stoneware Company.

In 1916, he went to Seattle as ceramic chemist for Denny-Renton. In 1928, he went to the Pacific Clay Products Company as ceramic chemist, which position he held until his death.

H. B. McMillen

SCHOOL NOTES

PENNSYLVANIA STATE COLLEGE

New Fellowship Established in Ceramics

A coöperative fellowship supported by the Findlay Clay Products Co., of Washington, Pa., has been established recently, for the study of certain fundamental technical problems of the company. The incumbent of the fellowship is Edward C. Henry who recently obtained his Ph.D. degree in the Department of Ceramics, Penn State, working under the direction of N. W. Taylor. Dr. Henry holds his B.S. degree from Rutgers University and an M.S. degree from the University of Nevada.

Graduate Students in Ceramics

There are at present eight students enrolled in the Department of Ceramics as candidates for advanced degrees. They are as follows:

George S. Bachman, B.S., Penn State College, candidate for M.S. degree.
Paul S. Dear, B.S., Virginia Polytechnic Institute, candidate for M.S. degree.
Bennett S. Ellefson, M.S., Univ. of Minnesota, candidate for Ph.D. degree.
Allen E. Martin, B.S., Univ. of Minnesota, candidate for M.S. degree.
Edward P. McNamara, B.S., Alfred University, candidate for M.S. degree.
Paul L. Smith, M.S., Penn State College, candidate for Ph.D. degree.
Milton S. Tarnopol, M.S., Mass. Inst. of Technology, candidate for Ph.D. degree.
Samuel Zerfoss, M.S., Penn State College, candidate for Ph.D. degree.

N. W. Taylor a Delegate to Glass Congress

As a delegate of the American Ceramic Society, Nelson W. Taylor attended the International Congress on Glass, held in London and Sheffield, England, July, 1936. Representatives of twenty-two countries were in attendance.

DR. WEYL TO TEACH AT PENN STATE

Woldemar Weyl has been appointed as Associate Professor in Ceramics to fill the position left vacant by the resignation of George J. Bair.

For the last few years, Dr. Weyl has been in charge of

the Division of Glass Research at the Kaiser-Wilhelm Institut für Silikatforschung. He is widely known for his work on the constitution of glass, particularly by the use of optical methods in these studies. This work has been done at the Kaiser-Wilhelm Institut für Silikatforschung and part of it in conjunction with W. E. S. Turner of Sheffield. The two men published a joint paper on the constitution and color of glass containing iron and manganese oxide.[1] In addition, Dr. Weyl has developed certain new analytical methods of glass analyses and has carried on some investigations on devitrification and on the nature of fluoride opals, as well as certain work on reactions in the solid state, reactions of carbon dioxide and silicates under very high pressures, and investigations on the changes occurring in the hydration and "souring" of dead-burned magnesite.

Dr. Weyl will be on leave of absence for a period of one year, but there is a possibility that he may remain permanently in this country. He arrived in America about the middle of August. He will be in charge of instruction and research in the field of glass in the Department of Ceramics at the Pennsylvania State College.

—NELSON W. TAYLOR, *Head, Department of Ceramics, Pennsylvania State College*

[1] W. E. S. Turner and Woldemar Weyl, "Constitution and Color of Glasses Containing Iron and Manganese Oxide," *Jour. Soc. Glass Tech.*, **19**, 208–16 (1935); *Ceram. Abs.* **14** [7] 159 (1935).

NOTES AND NEWS

PORCELAIN ENAMEL INSTITUTE ANNUAL MEETING

The sixth annual meeting of the Porcelain Enamel Institute, national association of porcelain enamel and allied manufacturers, will be held October 1 to 2 at the Hotel Statler in Cleveland, Ohio.

BOOKS ON ENAMELING

The Educational Bureau of the Porcelain Enamel Institute, 612 N. Michigan Ave., Chicago, announces the publication of four sample copies of booklets, which may be obtained, without charge, by anyone interested in the use of porcelain enamel.

Two of the booklets, Handbook on Design of Metal Parts for Porcelain Enameling, No. 1 and Reflectance Test for Opaque White Porcelain Enamels, are of a technical nature.

Porcelain Enameled Signs, another of the booklets, was published under the auspices of the Institute's sign division. It gives historical and background information regarding porcelain enamel and porcelain enameled signs, tells how they are made, and contains a summary of their uses and advantages. The booklet is profusely illustrated.

Nearing its third printing, the Institute's Sales Manual for Porcelain Enamel, discusses all phases of enameling.

AMERICAN SOCIETY FOR TESTING MATERIALS MEETINGS

The Fortieth Annual Meeting of the American Society for Testing Materials will be held in New York, N. Y., at the Waldorf-Astoria Hotel, from June 28 to July 2, 1937. The Fourth A.S.T.M. Exhibit of Testing Apparatus and Related Equipment will be held in conjunction with this Meeting.

The 1937 Regional Meeting and Committee Week will be held at the Palmer House, Chicago, Ill., March 1 to 5, 1937. —C. L. WARWICK, *Secretary-Treasurer*

APPOINTMENT OF ROBERT LINTON

Robert Linton, Consulting Mining and Industrial Engineer of Los Angeles, has been appointed member of the State Mining Board of California.

AMERICAN CERAMICS IN DENMARK

The Syracuse Museum of Fine Arts has been officially invited to assemble a representative exhibition of contemporary American ceramics to be shown next season at the Kunstindustri Museum in Copenhagen, Denmark.

This exhibition will be composed as far as possible of prize-winning pieces from the four previous National Ceramic Exhibitions (the Robineau Memorial Exhibitions) that have been held annually in Syracuse and of outstanding examples now owned by American museums.

In addition to the Fifth National Exhibition, this group will be on display at the Syracuse Museum of Fine Arts next fall.

The foreign showing has been planned with the cooperation of Ruth Bryan Owen, American Minister to Denmark, and Meta Lassen of Los Angeles, California, who brought the Danish Art Exposition to the United States in 1927.

EXPOSITION OPPORTUNITY

The American Association for the Advancement of Science and associated societies has invited members of the American Ceramic Society to contribute to and attend the Annual Science Exhibition, to be held at the Atlantic City Auditorium, December 28, 1936, to January 1, 1937. The Association pays the costs of booth rental for exhibits from educational institutions. Suitable commercial exhibits are also solicited.

CELO KYANITE
UNIFORM QUALITY DEPENDABLE SUPPLY
FOR INFORMATION AND SAMPLES WRITE TO
CELO MINES, INCORPORATED
BURNSVILLE, NORTH CAROLINA

THE FIFTH NATIONAL CERAMIC EXHIBITION

October 17 to November 16, 1936

This Ceramic Exhibition, The Annual Robineau Memorial, will be held at the Syracuse Museum of Fine Arts, Syracuse, N. Y., from October 17 to November 16, 1936. A selected group from the Exhibition, including the prize-winning pieces, will be circuited by the Museum following the Syracuse showing. During December, the Exhibit will be at the Worcester Art Museum and in January at the Cleveland Museum of Art.

The members of the Jury of Selection and Award are Richard F. Bach, *Chairman;* Arthur E. Baggs, William E. Milliken, and Anna Wetherill Olmsted.

Prizes

The prizes are (1) $100 for the best piece of pottery produced by a craftsman (offered by the Onondaga Pottery Company, Syracuse, N. Y.) and (2) $100 for the best piece of ceramic sculpture. Other prizes will be announced.

Entries

Entries must be received *not later than October 5.* Address them as follows: National Ceramic Exhibit (Robineau Memorial), King Storage Warehouse, Inc., 755 North Salina St., Syracuse, N. Y. Each artist is limited to five pieces (miniature groups to be an exception).

The entries may include work of any ceramic craftsman, provided it has not been previously exhibited at the Syracuse Museum. Ceramic sculpture of individuality is particularly desired.

Expenses

A fee of $2.00 will be charged each person who submits works to the Jury. No fees refunded if works are not accepted. As is customary, exhibitors are asked to bear the expense of transporting their entries to Syracuse and from Syracuse.

There will be no charge for packing or unpacking.

All works will be fully insured by the Museum.

In the event of sales, the Museum will charge a commission of 10%.

Preview and reception will be held at the Museum on Friday evening, October 16.

TWELFTH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

The twelfth National Exposition of Power and Mechanical Engineering will be held at Grand Central Palace, in New York, November 30 to December 5, 1936.

Equipment on display will include the following classifications: fuels, combustion equipment, refractories, steam generating equipment, steam distribution equipment, piping and fittings, prime movers, pumps and hydraulic equipment, electric generators and motors, electrical transmission, distribution, control, power transmission, control apparatus and precision instruments, power-driven machinery, tools and machine tools, material handling equipment, heating, ventilating, refrigeration, air conditioning, lubricants, operation, and maintenance materials.

LALOR FOUNDATION: FELLOWSHIPS AVAILABLE

The Lalor Foundation of Wilmington, Delaware, has announced the terms and conditions of five fellowship awards of $2500 each which will be granted for the academic year 1937–1938. Applications are to be in the hands of the Secretary, C. Lalor Burdick, by December 1, 1936, and appointments will be made in February, 1937.

The awards will be for research work in various fields of chemistry and related sciences. They may be used for work anywhere in the United States or abroad. As a memorial, however, to the late Arthur A. Noyes, founder of the Research Laboratory of Physical Chemistry at the Massachusetts Institute of Technology, one of the awards for each of the next four years will be specifically assigned to work at that Institution.

The Trustees of the Foundation share the opinion of many well-informed people that the energy today directed toward research in pure science is unduly small compared with the effort and money expended in industrial research and applied science. The Trustees have established this series of awards to aid men of established competence working in fields of pure science, thereby laying needed emphasis on scientific endeavor of a fundamental character.

Appointment is open both to men and women residents of the United States. No age limit is prescribed but the usual range of ages will be between 25 years and 40 years. Professors on sabbatical leave or other leave of absence are among those eligible for appointment. High intellectual and personal qualifications as well as creative ability and capacity for productive scholarship are essential elements in the appraisal of candidates.

The qualifications of the candidates will be passed upon by an Advisory Board comprising:

Roger Adams, Head of the Department of Chemistry, University of Illinois
Katherine Blunt, President, Connecticut College for Women
Harrison E. Howe, Editor, *Industrial and Engineering Chemistry*
Henry G. Knight, Chief, Bureau of Chemistry and Soils U. S. Dept. of Agriculture
Charles A. Kraus, Head of the Department of Chemistry, Brown University
Arthur B. Lamb, Professor of Chemistry, Harvard University.

The Lalor Foundation was organized in 1935. Its activities are maintained through income from a permanent endowment fund contributed by members of the Lalor family.

39th ANNUAL MEETING—MARCH 21–27, 1937
WALDORF-ASTORIA, NEW YORK CITY

COMMUNICATIONS—CERAMIC HISTORY

AMORY HOUGHTON, JR.

Amory Houghton, Jr., the founder of the Corning Glass Works, was born on October 20, 1837, at Cambridge, Mass. As a young man he was associated with his father, Amory Houghton, Sr., who had established a plant at Summerville, Mass., for the manufacture of glass. His desire to become proficient in the art of glassmaking led him to equip a laboratory in his father's factory for the purpose of experimenting in glass compositions, and the knowledge acquired at that time proved to be of great value in future years.

When his father sold his Summerville interests and bought a similar business in Brooklyn, N. Y., in 1864, known as the Brooklyn Flint Glass Works, Amory Houghton, Jr., moved to Brooklyn with him and was active in the new company until in 1868 the business was moved to Corning, N. Y., and established there under the name of the Corning Flint Glass Company. On account of his ability as a factory manager and his growing knowledge as a glassmaker, the younger Houghton carried much of the responsibility of the Company at Corning and when, in 1875, it seemed desirable to effect a reorganization of the Corning interests, he became President of the new concern which was incorporated as the Corning Glass Works.

Corning Glass Works 1875

The Corning Glass Works at first had but two furnaces and employed about 100 persons, but from that time, under the able management of Amory Houghton, Jr., it grew steadily in strength and also in importance in the industry. From time to time as the growth of the business required, additions were made to the plant until in the 1890's the melting units had increased from two to ten furnaces, and necessary enlargements of finishing rooms, pot and clay and mechanical departments, and power equipment were added to keep pace with the growing demands. A working force of about four hundred was then employed.

High Standards Maintained

Throughout this period of nearly a quarter of a century, the steady growth and progress of the Corning Glass Works was due to the personality and untiring efforts of its President, for Amory Houghton, Jr., although reserved by nature, was a man of high integrity, unusual strength of character, and keen business sagacity. So exacting were the standards he set that he would tolerate neither inferior quality in his products nor slackness in manufacturing methods. He never lowered those standards. As a result, the Company early established an enviable reputation for the production of glass of high excellence particularly in the lead glass field in which it specialized.

Trained Scientists Employed

The desire for quality of a high standard naturally led to the attempt to work out new formulas for the production of glasses which would meet the especially difficult requirements that arise in the trades for which the ordinary glasses were unsuited, and it is particularly interesting to note that when, in the search for these new types, the Company reached the limit of its ability to proceed further under the limits of the approved methods of glassmaking of the day, it had sufficient vision to seek the aid of trained scientists to assist in solving its new problems. A little later it was only a step to the establishment of its own laboratories and to the entrusting of its future to the results of scientific research. Faith and courage were required to do this, but the faith was more than justified.

Amory Houghton, Jr.

New Products

Among the many results of this decision, a few outstanding achievements may be noted; for example, the revolutionary work in the study of colors and glasses best suited for railway signal engineering, which has greatly increased the safety of travel by rail; the development of a series of low-expansion glasses of the borosilicate type, which have made possible the use of glass for exacting laboratory service, for cookery, for therapeutic and electrical use, and even for the 200-inch telescopic disk, which proved to be an undertaking of unique interest.

Died in 1909

His colleagues, particularly his two sons, ably carried on his established policy of excellency in product and a tireless search for improvement. The success, which began in his lifetime and which has since continued, has largely been made possible by the secure and substantial foundations which he, as the Company's first president, laid down.

—G. B. HOLLISTER, *Vice-President in Charge of Sales*

CHINESE KILNS THAT LAST FOR TWO FIRINGS*

Henry Jewitt Greene of Petersham, Mass., has had an interesting and informing experience in China which he has forwarded to the Secretary of the Society.

"About a year ago, I left China after several months of study of old and new pottery and porcelain. I visited many villages where pottery was made in almost every house and as this is an avocation of mine, I had a 'whale of a time.'

"A party of four of us went back in the mountains of Fukien to the village of Têh-hua and dug in some of the old kiln sites to try to establish a date for this well-known porcelain. As far as is known, we were the first foreigners interested in ceramics that had ever visited this country. It took several days to get there, as it is a long way up in the mountains which are full of bandits. This gave a little extra thrill to the expedition.

"I have shown the accompanying picture to many ceramists and so far I have not found one who has ever seen this type of kiln. It is fired from the bottom for 24 hours, wood being the fuel used. After this only a small hole is left for draft at the foot, and the rest of the firing is done in the holes on the sides which are about six inches in diameter. Beginning at the bottom, three holes at a turn are fired until the pottery has matured. These holes are then plugged up and the next three are fired and so on until the top is reached. Since the wood is cut in very small pieces and is as dry as powder, it burns almost with a flash. Some of these kilns for high-fired work last only one or two firings and never over ten times for this porcelain. The hills used for the kilns as a rule have a grade of about 45% (although this picture does not show it), and what a draft! They are about 125 to 150 feet long and from 8 to 15 feet inside."

—Henry Jewitt Greene, *Green Top, Petersham, Mass.*

* Received July 29, 1936.

Kiln in Teh-hua, Blanc de Chien, China, built for 10 firings and possibly only one or two.

THE CAUSE OF BRITTLENESS IN DE-AIRED HEAVY CLAYWARE

By H. R. Straight

The cause of the very noticeable increase in brittleness in de-aired clayware as compared to those not de-aired has been a matter under discussion in the industry for several years. A comparison of the de-airing processes now in use has been made, and it is believed that the cause has been traced to nonuniform evacuation of the air from the masses making up the body of the units.

It seems well established that in most clays there is a difference in the drier and kiln shrinkage between de-aired and nonde-aired clayware. It is easily understood that

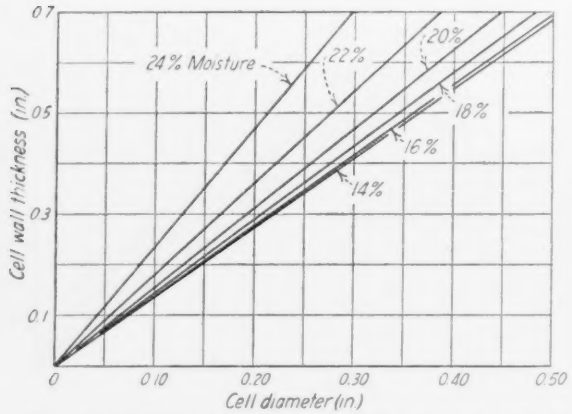


FIG. 1.—Cell diameters below which 14 pounds vacuum will not evacuate air in clays of strength and cell wall thickness shown.

Tensile Strength of Adel Clay with Varying Moisture Content

Moisture (%)	Strength (lb./sq. in.)
24	1.92
22	1.95
20	2.20
18	2.44
16	2.53
14	2.58

$D = S_t \times 4T$.
D = cell diameter (in.).
S_t = tensile strength/sq. inch.
T = wall thickness/sq. inch.

where the masses of clay are sufficiently large it is not possible for the air to force an exit from the inclosed air cells into the lower pressure surroundings. In short sandy clays there is comparatively little plastic strength and the differential pressure has sufficient force to open up channels into the lower pressure zones, but in clays of fair plastic strength the resistance to flow of the inclosed or roughly occluded air is believed to cause sufficient resistance to prevent the exit of the air.

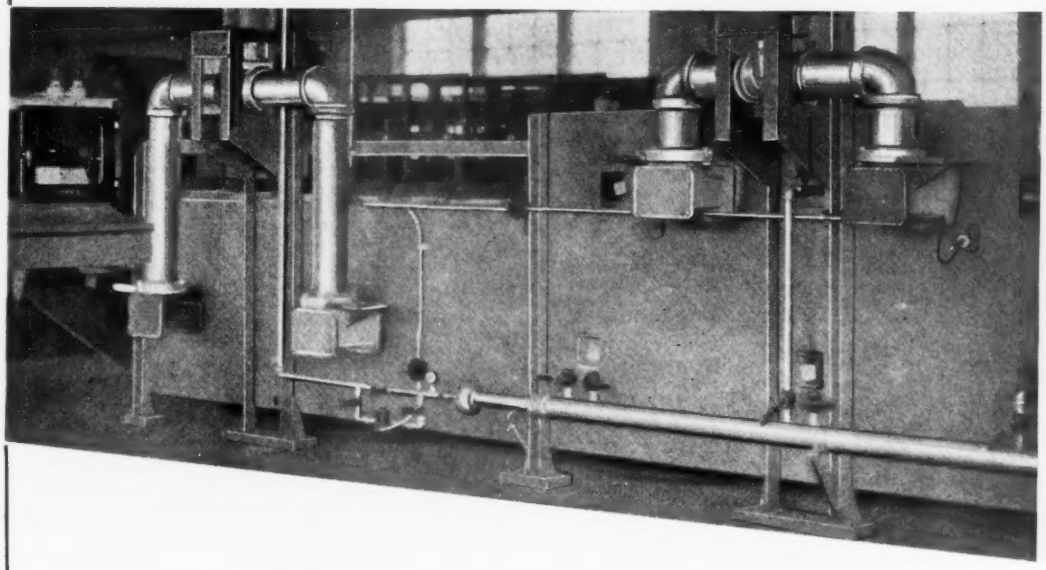
Figure 1 is based on a shale-fireclay mixture of approximate average plastic strength as used in the structural clay industry and seems to indicate clearly that where there are many masses as large as $^1/_2$-inch cubes the de-airing of the interior of such masses must be imperfectly accomplished.

Where masses of different degree of de-airing are molded into one unit, the stresses set up within the unit must of necessity be such as to tend to add to such external forces tending to cause breakage and chipping.[1]

The experience in the use of a machine which pugs the clay thoroughly under a vacuum has shown that this trouble in chipping is not found and the answer is believed to be in this method of de-airing.

ADEL CLAY PRODUCTS COMPANY
ADEL, IOWA

[1] See J. O. Everhart, "De-Airing Stiff-Mud Bodies for Clay Products Manufacture," *O. S. U. Eng. Expt. Sta. Bull.*, No. 74; *Ceram. Abs.*, **14** [6] 146 (1935).



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Time	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Forenoon			General Session	Division Meetings	Division Meetings	Division Meetings Trips	Trips
Noon		Board of Trustees and Committee Luncheons	(1) School Reunions (2) Committee C-8	Division Luncheons	General Committee Business Luncheon Meetings		
Afternoon	Board of Trustees	3:00 p.m. Ceramic Educators	4:00 p.m. Fellow Business Meeting	Division Meetings	Division Meetings	Trips	Trips
Dinner				Keramos Dinner Meeting	Dinner Dance all evening		
Evening		Small Concert	Get-Together Party	8:00 p.m. Installation of Officers 9:00 p.m. Orton Memorial Fellow Lecture	Dinner Dance		

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Calcspar
Chrome Oxide, Green
Clay, Vallendar
Cobalt Oxide, Black
Cobalt Sulphate
Copper Oxides
Iron Chromate
Iron Oxides
Kryolith
Lead Chromate
Magnesium Carbonate
Manganese Dioxide
Nickel Oxide, Black
Nickel Oxide, Gray
Nickel Sulphate
Potassium Bichromate
Potassium Nitrate
Potassium Permanganate
Powder Blue
Rutile, Powdered
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Sodium Aluminate
Sodium Antimonate
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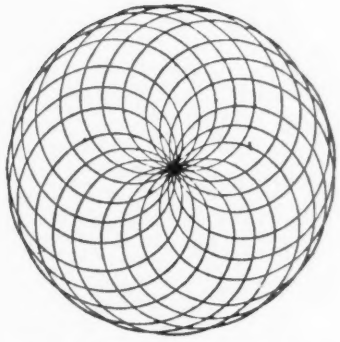

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